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CENTRAL STATES FOREST EXPERIMENT STATION



CENTRAL STATES FOREST EXPERIMENT STATION
FOREST SERVICE, U. S. DEPARTMENT OF AGRICULTURE
111 OLD FEDERAL BUILDING, COLUMBUS 15, OHIO

W. G. MCGINNIES, DIRECTOR

The Central States Forest Experiment Station is a part of the Forest Service, U. S. Department of Agriculture. Its purpose is to conduct research in all phases of forestry in the Central Hardwoods Region (Illinois, Indiana, Iowa, Kentucky, Missouri, and Ohio). This includes work in such varied fields as forest management, silviculture, planting, watershed management, disease, insects, fire, grazing, resource analysis, marketing, and utilization. The work is directed and coordinated from the main office in Columbus, Ohio, but most of the actual field work is done at and from the several branch offices located throughout the six states.

QUANTITY INTO QUALITY

In our Central States region forests occupy one-fifth of the land area. This 42.4-million-acre woodland is more than the entire land area of the six New England States -- a great deal of forest in a region that is generally regarded as agricultural and industrial. Unfortunately, this resource is in rather poor condition. The stands are producing only a fraction of what they should; forested watersheds are not effectively safeguarding our soil or regulating streamflow; forests are not providing the desired habitat for wildlife; and forests are not supplying adequate recreation facilities for our expanding population. We need the many products and benefits which the high-grade forest can furnish. One of the big jobs ahead is to transform our quantity into quality.

Fortunately, our region has soil, topography, and climate that are favorable to tree growth. These are the things that made it possible for the area to produce some of the finest hardwoods in the world. Today, these forests show many signs of the abuse and neglect that have gone on over the years. It has been estimated that the productiveness of the once high-quality forests has been reduced by about half. Timber types have changed, forest sites altered, hydrologic cycles disturbed, and wildlife conditions modified. This is the price that must be paid for past misuse. The situation is further complicated by the fact that most of the forest area is in hardwoods with more than 30 commercially important tree species represented. This forest community has been described as the most complex and oldest hardwood forest association. The diversity of species growing on a variety of sites creates many perplexing forest management problems. Superimposed on these natural problems are the numerous sociologic and economic situations that influence forest resource management.

Research begins with problems. Through research we try to find answers to these problems and to point out better ways of managing the forest resource. Much of our research effort has gone and is going into solving current practical problems. We get an idea and test it. These ideas arise out of our knowledge of basic laws and principles that operate in nature and in our society. Frequently, we find there are great gaps in this basic knowledge which hamper progress and development. More research is needed to bridge these gaps; research that will build up our reservoir of fundamental knowledge. Through research we can transform our problems into opportunities.

It is most important that our forest resource be managed so it will contribute ~~maximum~~ benefits to the region and the nation. In some of our most heavily forested areas, the per capita income is among the lowest in the country. Here the forests must be managed and used in a manner that will improve the local economy. From the national point of view we will soon need all of the products the forest resource can furnish to supply our expanding population. To do this our overall research program should be broadened and intensified.


W. G. McGINNIES
Director

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YEAR IN REVIEW

Our basic aim is to provide knowledge that will help people decide what forest resource management systems will best serve the needs of our region and nation. Our efforts seem small when we look at the many unanswered questions confronting us, but we are making progress. During the past year more than 50 publications were issued to help toward understanding and solving our many forest problems. This report reviews some of the published material and previews some yet to be published. A few highlights are briefed here.

DISEASE

Major emphasis in forest disease research has been to solve some of the problems associated with the oak wilt disease, and to make some preliminary investigations of root rot in pine plantations and of stem canker of yellow-poplar.

- Studies of the incidence of root-grafts in oaks appears to be too low to account for a very important portion of the oak wilt spread that occurs every year.
- Laboratory studies of oak wilt fungus in logs and lumber indicate that moisture content of the wood is a critical factor influencing fungus survival and growth.
- Current studies indicate that overcup oak is highly resistant to oak wilt infection.
- Several treatments to control root rot in shortleaf pine plantations are being tested.
- Indications are that at least two fungi (Nectria and Fusarium) are associated with stem canker of yellow-poplar.

ECONOMICS

Our forest economics research program includes studies in forest products marketing and timber production economics along with forest survey.

- In the marketing field, information was released on prices paid for rough timber products in Ohio, timber markets and marketing practices in Kentucky, pulpwood markets and prices. A simple method was developed to determine whether pulpwood or sawlogs were the most profitable markets for given sizes of timber.

● Studies were made in four different geographic areas to determine the attitude and characteristics of private owners of small woodlands. This information should help in the development of a program to get better forest management on our small forest tracts.

● An investigation is being made of the business, sales, and purchase policies of secondary handlers in the forest products business. It appears that concerns which have a variety of markets rather than a single market are in the strongest competitive position.

● The inventory phase of the resurvey of the forest resources of Missouri was started. This resurvey is designed to give a greater degree of correlation between results of new surveys and those of previous surveys. In addition, the new survey will provide data on a more local level than did the earlier survey.

FIRE

During the past year our fire research studies have been aimed at improving techniques for measuring burning-index ratings and reducing fire hazards that result from cultural operations.

● Wind velocity measurements based on a 10-minute recorded observation gave a suitable wind velocity measurement for burning-index computations.

● Shortleaf pine slash in Missouri lost about 95 percent of its needles 3 years after cutting. This loss of needles greatly reduced the flashy character of the fuel. However, even after 7 years of deterioration the slash is still contributing to the total surface fuel hazard.

INSECTS

In forest insect research our major emphasis is on studies of insect vectors of tree diseases, hardwood borers, defoliators, insect enemies of plantations, and insect detection surveys.

● In the laboratory it has been found that several species of barkbeetles that were contaminated with oak wilt fungus can infect healthy oak seedlings.

● Studies indicate that the red oak borer is one of the primary enemies of our upland oak. This borer is directly responsible for much of the degrade in oak, and the initial attacks by the young larvae pave the way for attacks by other hardwood borers.

- Forest insect detection surveys have been intensified to give us more accurate and up-to-date information about insect problems in the region.

MANAGEMENT

In forest management research our major emphasis is on the silvics and silviculture of hardwoods, which includes studies of the reproduction processes and growth characteristics of hardwood plant communities. Along with these are studies to find out how this biological knowledge can be applied to the forests. Such information will enable us to prescribe various management practices that are needed to develop profitable high-grade forests.

- Some early results from yellow-poplar, bur oak, and short-leaf pine seed source tests show that there are distinct variations in growth and survival of seedlings grown from seed collected at various localities.

- Reproduction in hardwood stands is usually abundant. All too often the reproduction is undesirable, for no orderly procedure was followed to create the conditions necessary for establishing desired reproduction. Results from several studies point out some of these conditions that are required for the establishment of reproduction either naturally or artificially.

- Studies have shown that in many forest stands the undesirable hardwoods can be controlled or eliminated at a reasonable cost using silvicides.

- Early results from studies in upland and bottomland hardwood stands shed some light on growth characteristics as they are related to stocking, structure, and species composition.

- Thinning studies in shortleaf pine plantations indicate that from the standpoint of total growth, thinning can be deferred until the stands are about 20 years old.

- The quality of oaks is directly related to the number, size, and arrangement of branches on the tree bole. Early results from release and pruning studies in pole-size, white and pin oak stands give some information on how the treatments effect bole branches.

PRODUCTS

Research in utilization has been primarily concerned with tree quality, efficiency of various timber-harvesting methods, seasoning of hardwood lumber, and finding new ways of using our hardwood lumber.

- A shortcut system is being developed for estimating quality of standing hardwood trees. The system is based on a quality determination of the best 10-foot section of the butt 16-foot log.

- An exploratory study was made of some of the problems encountered when air-drying lumber in unit packages. Indications are that pile width and board spacing have little effect on drying rate and development of degrade in lumber dried during the wet season (February-April). However, both pile width and board spacing affected drying rate and degrade in lumber dried during the dry season (July-September).

- Unit production costs of hog-feeders made from native oak are being compared with those of feeders made from softwoods. The construction methods using the simplest machinery and the highest amount of labor showed a combined material and labor savings of \$11 to \$13 in favor of red oak.

RANGE MANAGEMENT

Studies were begun in the western Missouri Ozarks to find answers to the conflict between grazing and forestry interests. The overall objective is to stabilize land use at a level of production in keeping with the land capabilities and the needs of the people in the area. Other studies have been primarily concerned with forage production.

- Reducing the hardwood crown cover to 60 percent or less resulted in relatively large increases in gross production.

- K-31 fescue is apparently better adapted to competition with hardwood sprouts than little bluestem. Two years after treatment forage production increased on plots seeded with K-31 fescue and decreased on plots seeded with little bluestem.

WATERSHED MANAGEMENT

Plans are underway to intensify our watershed management research, with emphasis on investigations which give us a better understanding of the basic laws and principles in plant-soil-water relations of the region. Priority will be given to studies of

subsoil water management, microclimate, vegetation and biotic factors as they affect development of forest soils, restoring soil stability, creating favorable runoff characteristics to deteriorated forest areas, and vegetative management for water yield.

● A soil-moisture study in southeastern Ohio has shown that clear cutting a mixed oak stand can affect water available for streamflow because it takes less dormant season precipitation to wet the soil enough for percolation of water to groundwater storage or become available for streamflow.

● An analysis of precipitation and runoff records for three small watersheds in Missouri showed that a water year June 1 to May 31 was best for predicting annual water yields.

DISEASE

Major emphasis in forest disease research in 1958 has been on the oak wilt disease, potentially the most serious oak disease in the United States (3,23,24,25)^{1/}. This work is being concentrated in Missouri where our staff cooperates closely with the University of Missouri on forest disease problems of mutual interest. Research effort on other forest disease problems is concentrated in Ohio, where attention is focused on diseases of pine and yellow-poplar.

OAK WILT PILOT STUDY

Of particular importance this year was the development of a study to evaluate the relative effectiveness of several different oak wilt control methods currently used in statewide programs in the eastern United States. This plan, formulated by the Forest Service in cooperation with six eastern states, is designed to measure the efficiency of local control around infected trees, as well as the effect of local control measures on long distance spread.

This Station, in cooperation with the Kentucky Division of Forestry, established first-year infection plots in 1958 and an equal number are to be established in 1959 and 1960. State control methods are applied to these and data will be collected on the spread of the disease within the plots. Also, a measure of the effect of these treatments on long distance spread will be obtained by making a complete air survey of county-size areas. The results of this study should provide a reliable basis for appraising the oak wilt control practices now in use.

ROOT-GRAFTS IN OAKS

A suspension of spores of the oak wilt fungus in a water solution of red organic dye was introduced into the stumps of 89 black oaks and 86 white oaks (fig. 1). The incidence of root-grafts, based on observed translocation of dye from treated stumps to surrounding trees, was 11 percent for black oaks and 17 percent for white oaks. One graft occurred between a black oak and a blackjack oak. All other grafts were between trees of the same species. Eight multiple grafts in which more than 2 trees were connected to a common root system were revealed. The maximum measured distance between 2 root-graft-connected trees in Missouri is 36 feet. No disease symptoms have been observed as yet in the trees known to be connected to the inoculated stumps.

^{1/} Numbers in parentheses refer to publications dealing with subjects mentioned. These publications are listed in the back of the report, beginning on page 59.

Figure 1.--A suspension of spores of the oak wilt fungus in a water solution of red organic dye is introduced into the stump of a freshly cut white oak.



Results of studies of root grafting conducted in 1957, using other materials and techniques, agree very closely with the results of this year's work. Even if all of the indicated root-grafts prove to be functional for disease spread, the incidence of grafting appears to be too low to account for very much of the oak wilt spread that occurs every year in Missouri.

OAK WILT FUNGUS IN LOGS AND LUMBER

Laboratory studies of the growth and survival of the oak wilt fungus are in progress as the first step toward devising treatments that will eliminate this organism from export products derived from diseased oaks. Current results indicate that the fungus can invade all portions of black and white oak sapwood, and to a lesser degree, heartwood. Wood moisture appears to be the primary factor limiting the survival of the fungus. The fungus survived longest when the wood moisture was 35 to 40 percent of the oven-dry weight, and few isolations were successful below 20 percent. The wood rays were apparently the principal avenues of fungal invasion; no mechanical or chemical breakdown was apparent as a result of such invasion. No interior sporulation of the fungus in wood was noted, but fruiting was frequently observed on the outer surfaces of blocks.

OAK WILT INFECTION IN WHITE OAK

Fifteen white oaks (Quercus alba) growing under nursery conditions were inoculated with a heavy spore suspension of the oak wilt fungus in June of 1957. After nearly 2 years observation, the indications are that in a fairly high percentage of white oak trees, oak wilt infection may occur without outward manifestation of the disease until the second year following infection. It also seems that typical foliar symptom development is not necessarily the sole criterion of infection. Stem dieback in the year following infection, however, appears to be a fairly common expression of infection. The results also indicate that some white oaks, in this case 20 percent, may become infected without showing any external evidence of the disease, at least during the first 2 years following infection. In every case, sapwood streaking was associated with infection regardless of external symptoms.

OVERCUP OAK RESISTANT TO OAK WILT

Oak wilt infection in overcup oak (Quercus lyrata) has not been reported. Five 2-to-3-inch, nursery-grown overcup oaks were inoculated in June 1955, and ten in July 1957, by introducing heavy spore suspensions into stem wounds.

None of the inoculated trees developed any symptom in its foliage that would suggest oak wilt infection. However, vascular streaking in the sapwood of scattered branches was evident in about half the trees by the end of the first growing season. A scattering of twig dieback, associated with vascular discoloration, was evident in the tops the year following inoculation. The fungus was recovered from these trees in both years but could not be isolated after 1956 from any of the trees inoculated in 1955. These trees have shown no further progression of the disease.

These results suggest that overcup oak is highly resistant to oak wilt infection. There has been no mortality and the trees appear to recover from the infections with little outward evidence of injury.

ROOT ROT IN SHORTLEAF PINE PLANTATIONS

Root rot of pine caused by Fomes annosus was killing many trees in Indiana shortleaf pine plantations. These had been thinned several years ago. In an effort to develop satisfactory control measures, all killed trees were removed and the stumps sprayed twice with either creosote, pentachlorophenol, or copper naphthenate. In the fall following treatment the fungus was found at the

soil level on several stumps as evidenced by fruiting structures, and one dying tree was observed. These occurred before the treatments were applied, however.

STEM CANKER OF YELLOW-POPLAR

Results of a taxonomic study indicate that a Nectria species is associated with the Fusarium species that apparently causes stem canker in yellow-poplar. The Fusarium species has been identified as F. solani. Several strains of Fusarium and Nectria are being used in monthly inoculation studies to determine their ability to produce typical canker symptoms and discover optimum periods of tree susceptibility (fig. 2).

Figure 2.--Inoculation
of yellow-poplar with
Fusarium solani.





Figure 3.--Farm forester assists woodland owner in appraising timber.

ECONOMICS

Our economics research currently includes studies of timber markets, forest land use and ownership, timber production surveys, and forest resource surveys. In addition, this year we completed forest economics research project analyses for eastern Kentucky and the Missouri Ozarks. The reports describe the economic conditions of the areas and recommend forest economic research programs aimed at getting the most profit from the forest resource in these two sections.

MARKETING

Farm Woodlot Timber Sales

Case studies of farm timber sales from Ohio indicate that a farmer can expect to get more profit from his woodlot by:

First, accurately determining the quality and quantity of timber he has for sale and the kind of products to be sold with the aid of the Farm Forester or some other trained forester (fig. 3). (51).

Second, obtaining as many bids as he can for his products.

Third, doing as much of the work as possible himself.

Prices for Ohio Timber Products

In 1958 the first timber product price report for Ohio was released (29). This report provides the timber owners of Ohio with a guide for the relative value of their standing timber and cut products (fig. 4). In addition, the report includes a resume of the grades and specifications used in buying timber products. However, buyers' specifications vary widely, even within a specific industry, so the prices paid timber owners will vary with the product and the buyer making the purchase.

Kentucky Directory of Timber Buyers

Many timberland owners are not familiar enough with the market to effectively sell their standing timber. In an effort to help these people, the "Kentucky Directory of Timber Buyers" was published by the Kentucky Department of Economic Development (38). It was made possible by the cooperation of the Central States Forest Experiment Station and the Kentucky Division of Forestry. Listed are 750 buyers of primary forest products now actively buying stumpage and primary products. In addition, product specifications are discussed and a brief outline is given of the technical forestry guidance available to woodland owners in Kentucky.

Sales Characteristics Affect Average Stumpage Prices

Some of the things that influence the price paid for saw-timber stumpage are controlled by the seller. Exploratory studies of the effect of seller-controlled circumstances have been made for competitively sold timber on the Cumberland National Forest. Preliminary results show that there is a direct relation between average stumpage price and the volume per acre marked, species composition, and size of the average tree; an inverse relation between stumpage price and area of the sale; and no relation between stumpage price and total volume of the sale for sales between 100 M b.m. and 1,500 M b.m.

Plans are to extend this work to private sales.

Figure 4.--Ash
handle logs
such as these
were worth from
\$60 to \$100
delivered at
Ohio markets
in 1958.



Pulpwood or Sawlogs from Small Hardwood Trees

Because most trees can be cut and sold for one of several products, the woodland owner has a choice to make. Little research has been done to help him in this choice when selling small hardwood timber. A first step was made by equating various unit volumes of sawtimber measure with the various pulpwood units for hardwood trees of different sizes. Values of pulpwood or sawlog products can be compared by relating unit prices to their respective volumes and performing the simple calculations given in the publication (51). This work is being continued for other products.

Pulpwood Markets and Prices

The growth of the pulpwood industry in the Central States over the past few years has provided markets for small-diameter hardwoods in areas where this type of timber formerly had little or no market value.

Although there are many pulpwood markets, most of the wood purchased by Central States pulpmills is bought under quota contracts. A small individual timber owner seldom can sell directly to a mill.

There are now 25 mills that purchase pulpwood in the Central States. In 1957 these mills purchased nearly a quarter of a million standard cords of pulpwood. Based on prices paid at the mill, the value of this wood amounted to more than 3 million dollars (31).

The prices paid for pulpwood in the Central States vary according to buying point, condition of the wood (unpeeled or peeled, green or dry, slabwood, roundwood, or chips), the mill itself, and the unit of measure used. There are three units of measure used in purchasing pulpwood in the region: Long cord or unit, standard cord, and ton. Pulpmills were paying from \$5.20-\$7.00 per ton, \$11.00-\$18.00 per standard cord, and \$11.50-\$16.50 per long cord for unpeeled, round pulpwood delivered to the mill in 1957 (30).

Forest Products Market Structure

A study is being made of the business, sales, and purchase policies of secondary handlers in the forest products business. This study should reveal some important facts concerning the forest products market structure and additional information that will

be useful in business appraisals. From the incomplete data collected in Kentucky it appears that concerns which have a variety of markets rather than a single market are in the strongest competitive position. Business of single market firms fluctuates widely from year to year while the multiple market firms are more stable as evidenced by their continuing expansion.

Ohio Consumer's Choice of Christmas Trees

Scotch pine is the most popular Christmas tree in at least three of Ohio's largest cities. Nearly 40 percent of 600 consumers interviewed in Cleveland, Columbus, and Cincinnati preferred this species. Balsam fir came next and red pine was considered least desirable. Most sought-after characteristic aside from general appearance was needle-holding ability. Other things that influenced buyers were species, density, color, needle length, price, grade, and such intangibles as custom or family background.

About two-thirds of the Christmas-tree users interviewed preferred a perfect or premium-grade tree. However, about 20 percent of the families making less than \$10,000 annually admitted they would switch from a premium-grade tree to a lower grade tree if the premium tree cost half again as much as the lower grade tree (35).

Christmas-Tree Retailing in Ohio

Christmas-tree retailing is an important seasonal operation for grocery stores, fraternal organizations, service stations, Christmas tree growers, and others. In order to get some information on retailing practices, about 80 Christmas tree retailers in Canton, Columbus, and Washington Court House were interviewed in December 1956. It was found that retail lots are usually located on a parking lot adjacent to the permanent business, or if the retailer does not have a permanent business, on a vacant lot in a residential area. Christmas-tree lots were open 8 to 50 days; with the average being 17 days.

Most retailers handled several species of trees which were purchased from local wholesalers. Generally, the trees were bought by species and size; however almost three-fourths of the retailers stated they would also like to buy on a quality basis. Some contract for trees throughout the year, but most buy their trees in December (39).

Both of these Christmas-tree marketing studies were done in cooperation with the Ohio Agricultural Experiment Station.

TIMBER PRODUCTION ECONOMICS

Forest Ownership

"Timber Resources for America's Future" drew sharp attention to the fact that privately owned woodlands must provide a major part of any increase in timber production in the United States. More than 90 percent of the commercial forest land in the Central States is in private ownership.

How can the thousands of individual owners with small forest holdings be persuaded to do a better job of timber management? To help answer this vital question, a study of forest landowner attitudes and ownership characteristics was made for selected counties in Ohio, Missouri, and Kentucky. One study in a good agricultural area in Ohio revealed that the owners have too many alternative uses for the land to be interested in forestry. Often they wanted to clear woodland for pasture or cropland. Most of the forests were on land valued at \$200 to \$350 per acre. Another Ohio study in the less valuable hill land showed that while owners there are more interested in growing timber, they are reluctant to invest in improvement practices.

Business and professional people control the largest area but farmers are the most numerous single occupational class of woodland in the Missouri county studies. Three-fourths of the landowners do not contemplate practices likely to increase forest production over the unsatisfactory levels common today. Those expressing intent to grow timber gave little evidence of conviction.

The average age of the landowners in the eastern Kentucky counties studied was 50 years, but their tenure was only an average of 14.5 years. Even though owners of small farms needed to graze their woodlands, most owners listed timber growing as their primary intent. In most cases this was a passive intent, not contemplating any cultural operations.

Conclusions and recommendations made by those conducting the study include:

1. Forestry programs should be strengthened in the rough hill lands rather than in valuable farming areas where present-day forest land is frequently suitable for alternative uses.
2. Educational and extension efforts should be chiefly aimed toward groups who control the most land in poorer farming areas.

3. Research is needed in "short-term" forestry.

4. Research is needed to find out how to convince small woodland owners that managing their forest land will pay.

FOREST SURVEY

Early in 1958, forest survey field crews began the inventory phase of the resurvey of the forest resources of Missouri to bring the 1946-48 forest resource information up to date. Unlike the initial survey, the resurvey is designed to allow for continuous inventories. Permanent plots will be established that will facilitate taking remeasurements at shorter intervals. This new system will also provide a greater degree of correlation between the results of new surveys and those of previous surveys. Changes in the volume of species, types, and densities because of growth, mortality, cutting, and regeneration can be reported more accurately and more frequently. Statewide interest in the resurvey of Missouri has resulted in a demand for a more intensive survey to provide more localized data.

We completed and sent to the publisher the forest resource and industry report for Iowa. With this report the first timber resource survey of all of the Central States is completed. This year, we also completed a pulpwood production canvass of all mills obtaining pulpwood in the Central States.

FIRE

We need better information on fire behavior, fire-danger rating, and fire effects in the Central States (14). Studies during the past year have been aimed at improving the techniques for measuring wind velocity and reducing the fire hazards that are created by cultural operations.

WIND-VELOCITY MEASUREMENTS

Wind velocity changes frequently and rapidly so some arbitrary standards of measurement must be used to get a satisfactory wind-velocity reading for computing burning index. Standards vary by regions, but more weight has been given to the location of wind-measuring instruments than to the duration of reading.

In studying wind-measurement problems we found no significant difference in velocity measurements from anemometers on the same site but located according to two different regional standards for exposure. Of much more importance was the range of 1-minute velocities found within a 10-minute period. Ten-minute mean velocities were similar for both instrument locations. But two consecutive 1-minute observations at either location gave a difference of 20-30 points in burning index on the Central States Danger Meter.

Obviously a 1-minute observation is too short, but many burning indexes are derived from 1-or-2-minute observations, so errors may be common especially when there are gusty winds.

The optimum length of observation is hard to determine. After checking all the possible 10-, 15-, 20-, 30-, and 60-minute running average velocities in a sample 3-hour period, however, it seemed apparent that there was little to gain by taking observations longer than 20 minutes.

WIND VELOCITY IS RELATED TO FIRE OCCURRENCE IN MISSOURI

Wind velocity, relative humidity, and fuel-moisture content all influence fire occurrence in Missouri. This is shown by an analysis of 3 years of weather records for Salem, Missouri, and of fire records for the same period on five nearby Missouri National Forest ranger districts.

Dry fuel and dry air increase the probability of a fire starting almost anywhere. However, in Missouri the striking increase in fire occurrence with increasing wind velocity is



Figure 5.--Wholesale poisoning of hardwoods competing with young pine creates a difficult fuel problem by increasing the light surface fuels and adding many new snags.

probably because many of the fires are escape burns. Looking to the future, wind velocity may become less significant as an indicator of fire probability as the people of Missouri become more careful with fire and if the practice of burning continues to decrease. For the present, however, wind velocity must be considered an important factor in fire occurrence.

CULTURAL OPERATIONS INCREASE FUEL HAZARD

Cultural operations, such as girdling or poisoning cull or other unwanted hardwoods (fig. 5), heavy thinnings, and logging operations, increase the amount of fuel on an area. The increased fuel is in the form of more grass and herbaceous vegetation and more dead hardwood trees. The dead hardwoods become snags that require several years to fall apart and disappear. They greatly increase the chance of spreading fire by spotting. And each year they drop a new supply of branch wood, thereby helping to maintain the quantity of surface fuels at a high level.

There are several ways to cope with this problem. Well-spaced, untreated strips could serve as fire retarders and as places to begin suppression. Use of heavy equipment for controlling fires in these areas would be desirable because construction of hand fire lines would be slow and difficult. Trail maintenance, i.e., removing trees and large limbs that fall across them to assure ready access, should be given top priority.

DETERIORATION OF SHORTLEAF PINE SLASH

Shortleaf pine slash in Missouri loses about 95 percent of its needles in 3 years after cutting according to observations on slash from thinnings made in 1951 (fig. 6). Shedding of needles greatly reduces the flashy character of slash fuels and the threat of damage by fire. However, even after 7 years of deterioration, the slash fuels are still contributing to the total surface fuel hazard. Since the aerial parts decay slower than slash on the ground, the duration of increased fuel hazard can be reduced by lopping the slash.

EFFECTS OF PRESCRIBED BURNING IN YOUNG PINE STANDS OF MISSOURI

A natural stand of 12-year-old shortleaf pine was thinned noncommercially, leaving an accumulation of slash fuels. A prescribed burn in April 1953 done under optimum weather and fuel-moisture conditions, greatly reduced the amount of light flash fuels with little apparent damage to the residual pine. Wildfire under more extreme conditions could easily have top killed the pine. Most of the small hardwoods growing with the pine were top killed.

Past research has shown that elimination of hardwoods from the understory of a shortleaf pine stand will increase growth of the pine. To find out if it might be possible to control the hardwood understory with fire, the area was burned in April 1956 and again in April 1958. Although both fires top killed the hardwoods, the trees still continue to resprout. Sample plots are being maintained in both burned and unburned areas to determine the effect of fire on growth and survival of pine and hardwoods.



Figure 6.--After thinning there is a moderate amount of slash in this shortleaf pine stand, even though the pine was utilized to a 3-inch top. The flashy character of the pine slash is greatly reduced after 3 years when most of the pine needles have dropped

INSECTS

Purpose of our research on the insect enemies of trees is to find out how to prevent or reduce losses to commercial hardwoods in the Central States. Insects currently being studied include the vectors of tree-killing diseases such as oak wilt and Dutch elm disease (49, 52), stem borers that lower the quality of sawlogs, defoliators that reduce growth and vigor, and the seed and root feeders that limit forest reproduction.

Although our studies emphasize hardwood insects, those damaging pines and other softwoods are also receiving attention. Moreover it is anticipated that the increased planting of pines in the Central States may create a greater need for research on such insects as pine sawflies and tip moths.

SPREAD OF OAK WILT BY INSECTS

Laboratory tests are being made to find out what insects might spread oak wilt (4, 5, 6). Several species of barkbeetles that were contaminated with the oak wilt fungus have infected healthy oak seedlings in the greenhouse. Thus, it appears that these insects can be vectors.

RED OAK BORER - PRIMARY ENEMY OF OUR UPLAND OAK

In the light of new findings, the red oak borer, Romuleum rufulum, now seems to be the most important borer species damaging the wood of black, scarlet, and red oaks. The carpenterworm will now have to take a back seat. In terms of degrade the two species rank about the same, but were it not for the red oak borer, the carpenterworm would probably be reduced to almost insignificant numbers. Other borer species rank very low in importance.

Tests have shown that less than 1 percent of the newly hatched carpenterworm larvae penetrate the outer dead bark. Only after attaining a greater size ($3/4$ to 1 inch in length) are they able to bore through the outer bark. The newly hatched larvae of the red oak borer on the other hand readily bore directly through to the living tissue from the point where the egg was deposited on the tree. Hence the young carpenterworm larvae nearly always work in wounds made by the red oak borer.

It was also found that many of the more recent red oak borer holes are invaded by larvae of the sap-feeding beetles, chiefly Glischrochilus quadrisignatus. This occurred in the late spring of 1958 when the red oak borer larvae were still boring in the



Figure 7.--Beetles caged on trees to test systemic treatments.

inner bark and cambial region. The sap-feeding beetle larvae create a soured sap medium that apparently killed some of the red oak borers. Apparently close to half the surviving red oak borer population was killed in this manner. This combined attack is the main cause of a defect in the wood known as a bark pocket, ingrown bark callous tissue 1 to 3 inches in diameter with associated wood stain. Heretofore, this kind of injury was blamed on other borer species. Control of the red oak borer should mean the elimination of much of our wood degrade.

SYSTEMICS FOR CONTROL OF BORERS AND BARKBEETLES

Although our primary concern is with forest-tree insects, many of the trees indigenous to central hardwood forests are also popular as shade and ornamental trees. Their insect enemies are the same but methods of control are different. Insecticide spraying, although effective, has its limitations. So for several years we have been testing different chemicals introduced into the sap stream (systemics) in an attempt to find a more efficient way to control tree insects (fig. 7). Results so far are not conclusive but appear promising (17, 18).

Although many tests failed because some chemicals harmed the tree and others were ineffective, some gave a fair degree of control. On locust and elm we found leafhoppers easily eliminated, twig-feeding barkbeetles moderately restrained, and internal borers apparently unharmed by systemics. Black locust and elm have been used as test trees because they are heavily attacked by several insect species and are readily available for tests with chemicals.

The systemic action of certain chemicals on elm was measured by a barkbeetle-feeding test. This consisted of placing ten twigs in a jar with 25 beetles. The tabulation below shows some of the chemicals used and the results of the test:

<u>Chemical</u>	<u>Feeding Scars</u> (Number)	<u>Effect on beetles 3 days</u> <u>after treatment</u>	
		(Alive)	(Dead)
Chipman R-6200	6	--	All
Chipman R-6199	5	--	All
Phosdrin	10	--	All
Nicotine Sulfate	15	13	12
Thimet	13	11	14
Systox	16	12	13
None	24	16	9

Soil treatments with systemics around black locust trees did not kill borers within the tree. This was found out by cutting 39 treated trees into small pieces and picking out every borer. The distribution of the borers within the tree is shown below:

Summary of the Total Data from 39 Trees

<u>Bolt-diam.</u> <u>class</u>	<u>Number of</u> <u>attacks</u>	<u>Number of</u> <u>galleries</u>	<u>Number of</u> <u>larvae</u>	<u>Number of</u> <u>12" bolts</u>
Up to 1"	766	380	191	1,587
1 - 2"	388	706	490	430
2 - 3"	216	308	173	156
3 - 4"	148	169	100	61
4 - 5"	23	25	12	12
5 - 6"	11	44	30	9
6 - 7"	0	4	4	1

Many attacks are unsuccessful and only scars remain. On the other hand, when the attack is followed by successful establishment of the larva, the gallery formed often removes the attack scar. Hence, there is an apparent lack of relation of attacks to galleries.

Since trees vary in size, even in an even-aged stand, the borer attack cannot be compared by whole trees. If we calculate the bark area of each tree and divide the total larval count by this area, we have a unit of comparison. Larvae per tree varied from 2 to 64 and tree areas varied from 3.1 to 28 square feet.

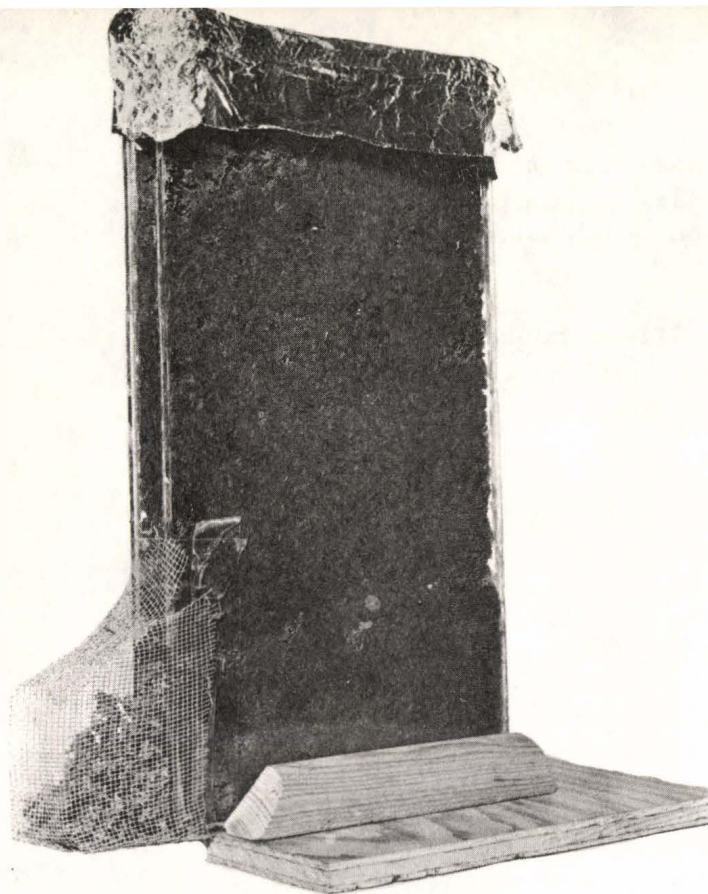


Figure 8.--"Wood burger" used to rear carpenterworm and larvae of other boring insects. (Photo courtesy University of Missouri.)



Figure 9.--Carpenterworm larva in "wood burger." (Photo courtesy University of Missouri.)

TECHNIQUE FOR STUDYING TREE-BORING INSECTS

A technique for studying the carpenterworm and other tree-boring insects in the laboratory was developed in cooperation with the Department of Entomology, University of Missouri. The larvae are grown in a "wood burger" (fig. 8). This consists of a glass-walled container about 10 inches high, 6 inches wide, and $\frac{3}{4}$ inch thick, filled with about 200 grams of sawdust from the host species thoroughly mixed with 20 grams of agar in 1 liter of water. The larvae enter through a small hole in the corner of the container where the frass is caught in a wire basket. The glass sides of the container make it possible to observe the activities of the larvae (fig. 9) (40).

PINE TIP MOTH

Pine tip moth is considered a major deterrent to reforestation thousands of acres of idle land to pine. At present, there is no practical control. Recent exploratory studies, in cooperation with the University of Missouri, the Missouri Conservation Commission,

and chemical companies, have provided some encouraging leads. A demonstration planting at the State Forest Nursery was made free of tip moth by the use of 4 pounds actual DDT per 100 gallons of water applied when the first eggs were ready to hatch in the spring. Also, Malathion 57 percent emulsifiable concentrate at 1 gallon in 300 gallons of water gave excellent control. Preliminary experiments with systemics indicate considerable promise for this method also.

FOREST INSECT DETECTION SURVEYS

The forest insect survey crews and field reports from State, private, and Federal agencies failed to uncover any new insect problems of major proportions. However, stands of hardwoods in southeastern Missouri, southern Illinois, western Kentucky, and localized areas in Ohio were found badly damaged by foliage-feeding insects, including defoliators, skeletonizers, leaf miners, and leaf rollers. Oaks were reported dying from repeated defoliation since 1952 in a 5,000-acre area in the vicinity of Salem, Missouri.

Insects continued to be a major threat to pine in the Central States. Shoot moth, sawfly, and bagworm were the most frequent causes for concern in northern Ohio and Indiana, followed by pales weevil, Ips beetle, webworm, Zimmerman pine moth, and the pine weevil (Pissodes approximatus).

In the southern portion of the Central States area two species of pine tip moth (Rhyacionia frustrana and R. rigidana) are causing greatest concern, followed by sawfly, webworm, Ips beetle, pine needle miner, black turpentine beetle, and the pales weevil. With the exception of the pine tip moth, most pine insect infestations are limited to portions of plantations or pine stands

MANAGEMENT

Most of our reportable work in management this year was in the general fields of silviculture and mensuration. But for the sake of convenience, we have broken it down into six classes: Natural regeneration, seeding and planting, silvics, stand-improvement methods, tree improvement, and yield and quality.

NATURAL REGENERATION

Natural Reproduction in Well-Stocked Hardwood Stands

Much of the advanced reproduction in the well-stocked, mixed mesophytic forests of the region is undesirable from the timber-production standpoint because of poor species composition. This is true partly because some of the overstory stands are poor in composition and partly because stand conditions seem to favor reproduction of the less desirable, more shade tolerant species. Many stands contain enough reproduction, as evidenced by recent observations in Indiana and Kentucky, but the number of trees of poor species usually far exceeds the number of good ones (fig. 10).

Generally, the first chance the forester has to do anything about this situation is during and immediately following logging. But the question is: What to do, and when? As one step toward finding the answer, we are closely observing and recording the development of natural reproduction in group-selection openings on the Hoosier National Forest. The openings are about 1/3 acre each. After logging, all culls and undesirable overstory trees were killed in the openings. The amount of desirable and undesirable reproduction varied by cutting area and site. On one cutting area there are 20,000 trees and shrubs per acre in the understory 1 year after logging. Also, a dense cover of herbaceous annuals and perennials developed during that first growing season (fig. 11). This growth competes with new seedlings and deteriorates the seedbed.

Sample counts in 15 clear-cut, 1/2-acre plots show that abundant reproduction follows complete clear cutting in southeastern Ohio's upland hardwoods (table 1) (33). Before cutting the plots were covered with an even-aged, mixed oak forest, approximately 90 years of age. The basal area of the sawtimber-size (12 inches and larger d.b.h.) trees ranged from 44 to 94 square feet per acre, with an average of 65 square feet. Ninety percent of the sawtimber-size trees were mixed oaks: White, black, scarlet, and chestnut. The plots are situated on ridgetops, upper slopes, and mid-slopes and are exposed to all aspects.



Figure 10 (above).--The understory in this well-stocked, mixed-hardwood stand contains 15,000 trees and shrubs per acre, but 90 percent are undesirable for timber production.

Figure 11 (below).--Annual and perennial herbs, shrubs, and trees form a very dense cover in a forest opening 1 year after logging.

Table 1.--Average density and frequency of seedlings and sprouts on clear-cut plots, southeast Ohio

Species	Number per acre	Frequency ^{3/}
Oaks ^{1/}	6,190	84
Yellow-poplar	2,010	50
Shortleaf and pitch pine	130	9
Hickory, red maple, and blackgum	2,610	62
Others ^{2/}	230	13
Total	11,170	99

^{1/} White, black, scarlet, chestnut, red, and post.

^{2/} Aspen, ash, black cherry, black walnut, and beech

^{3/} Percent of sample milacres containing one or more seedlings or sprouts.

All merchantable trees were harvested and the remaining trees larger than 4.5 feet in height were either cut or killed. The cutting was done in the spring and early summer, and reproduction counts were made at the end of the second growing season thereafter.

On all plots the amount and distribution of desirable reproduction are adequate, although the numbers and species vary widely. The total number of stems ranges from 4,900 to 21,300 per acre. Within species groups the number per acre ranges from 1,300 to 18,100 for oaks, from 0 to 8,300 for yellow-poplar, and from 100 to 5,000 for the less desirable species (hickory, red maple, blackgum). Apparently aspect and slope position had little effect on either the number of stems or species composition.

Two growing seasons after harvest cutting the total amount of reproduction had more than doubled in both mixed-hardwood and oak-hickory stands in eastern Kentucky. Although the bulk of this increase was of undesirable species, there is still an abundance of desirable reproduction fairly well distributed throughout the stands. In the mixed-hardwood type, 70 percent of all the quadrats sampled had one or more desirable seedling or sprout. Similarly, in the oak-hickory type 65 percent of all quadrats sampled had one or more desirable seedling or sprout. Of course, the increased numbers of undesirable trees and shrubs since cutting will compete with the desirable reproduction. Later measurements will show the seriousness of this competition.

Reproduction in Bottomland Hardwoods

While tree reproduction in our bottomland forests in southern Illinois is usually plentiful with several thousand seedlings and saplings per acre, the species composition here too is sometimes undesirable. Elm reproduction is commonly found in large numbers under the widest range of conditions; whereas, plentiful cottonwood reproduction usually occurs only on recent alluvial deposits.

Cooperative studies with Southern Illinois University showed that seedling reproduction 1 and 2 years of age was equally plentiful under all degrees of shading from the tree canopy. On the other hand, older seedlings and saplings were much more plentiful in openings at least 1/10 acre in size or larger (fig. 12). Reproduction of more tolerant species such as elm, hackberry, miscellaneous shrubs, and even green ash continued to persist for 5 years or longer under a closed canopy. However, seedlings of more intolerant species such as cottonwood, silver maple, pin oak, sycamore, and sweetgum apparently did not survive under a closed canopy. Cottonwood reproduction was also very scarce on areas with heavy ground vegetation.

Figure 12.--Green ash sapling reproduction in a 1/10-acre opening 6 years after cutting. Much of the ash was present as seedlings 1 to 4 feet tall at the time of cutting.



Litter depth definitely affected the abundance of reproduction. Cottonwood, willow, and sycamore were virtually absent on areas with litter more than 1/2 inch deep. Litter more than 2 inches in depth retarded reproduction of all species, but elm, hackberry, and the oaks were least affected.

Cottonwood and willow reproduction was well represented only on soils with a low-moisture-holding capacity (light soils). Conversely, hickory-pecan and oak reproduction definitely was more abundant on the heavier soils. Part of this was probably because of differences in seed supply.

Harvest and improvement cutting and killing of cull trees have had a beneficial effect on reproduction (36). In partially cut stands where the culls were girdled, the number of saplings increased from about 100 to 1,000 per acre in a 3-year period. Openings of 1/4 acre or larger that happened to coincide with low spots on the forest floor often had well-developed cottonwood reproduction.

Ax-girdling of cull trees less than about 14 inches in diameter resulted in copious and rapid sprout growth that tended to quickly occupy the area and retard the establishment of desirable reproduction. Subsequent treatment of the sprout clumps with ax frill and 2,4,5-T killed them and freed the area for new reproduction (fig. 13).



Figure 13.--Sprouts killed by 2,4,5-T in an ax frill. These sprouts originated from ax-girdled cull trees and were only 3 years old at time of killing with 2,4,5-T.

Figure 14.--A survey showed 70 percent of the advanced oak reproduction in upland stands of Illinois made slow growth and had poor form. This white oak stem was 11 years old and 2.5 feet tall.



No Difference Between Fall and Spring Scarification For Yellow-Poplar Reproduction

Spots scarified in April contained as many yellow-poplar seedlings as spots scarified in September in a trial in Indiana. Seedbed requirements for yellow-poplar are well known but the effect of season of scarification has not been firmly established. The test was made in a second-growth stand with an excellent yellow-poplar seed source. A seedling count made in mid-June showed no difference between fall and spring scarification. The unscarified check plots contained only one-fourth as many seedlings as the scarified plots. Further tests are needed in other areas and in different seasons to firmly establish the relationship between season of scarification and seedling establishment.

Stem Form of Advanced Oak Reproduction

Oak reproduction grows slowly under the closed canopies of oak-hickory forests in the Central States region. Slow growth and frequent dieback of the terminal shoots result in forked, crooked, multiple, or otherwise malformed stems (fig. 14). In southern Illinois a study was begun to find ways of replacing the malformed stems of advanced reproduction with fast-growing stems of good form.

In a clear-cut opening (0.4 acre), a partially cut stand, and an uncut stand we cut the stems of malformed reproduction and saplings up to 10 feet tall at ground level. The average age of these cut stems was 10 years and the average height was 2.3 feet, indicating very slow growth. During the first growing season the

sprouts from these rootstocks grew fastest in the clear-cut opening and slowest in the uncut plot. In the first year the sprouts regained 60 percent of the height of the original stems in the clear-cut opening, 40 percent of the original stem height in the partially cut plot, and 20 percent of the original stem height in the uncut plot. Furthermore, the height growth of the sprouts was directly related to the height of the original stems, but the sprouts were straighter and had better form.

In the same year the height growth of uncut reproduction and saplings averaged less than 1 foot in all plots. Results of future measurements will show whether the sprouts will eventually outgrow the uncut reproduction and produce better trees.

Yellow-Poplar Reproduction as Affected by Light, Overstory, and Forest Floor Competition

Good yellow-poplar reproduction was obtained in mixed-hardwood and oak-hickory stands where ground was scarified. Three years after treatment the mixed-hardwood plots average more than 5,000 and the oak-hickory plots more than 3,000 yellow-poplar seedlings per acre. Yellow-poplar seed trees are generally close to all plots. The number of yellow-poplar seedlings per plot does not appear to be related to the density of the overstory canopies, but the height of the seedlings is related both to light conditions and to the degree of competition on the forest floor. More than 400 such plots have been examined.

Good yellow-poplar growth has occurred only where: (1) The trees are in openings in the canopy, (2) there is strong light at least part of the day, and (3) there is little brush. Openings of 5,000 square feet allow about 40 percent of full sunlight, and in such locations yellow-poplar seedlings grow well.

SEEDING AND PLANTING

Direct Seeding of Shortleaf Pine in Missouri

In years with adequate rainfall during the growing season, direct seeding of shortleaf pine has been very successful in the Missouri Ozarks. A 90-percent "catch" was obtained on seed spots made on forest sites in 1941-42. After 14 years, 87 percent of these spots still were stocked, and the tallest trees were nearly 20 feet in height. Seedings done during the following year, which was very dry, had much poorer survival. After 14 years, these trees were only 16 feet tall.

In good years, direct seeding generally was successful regardless of the month of seeding--December, February, or March. During dry years, however, only the December seedings were reasonably successful. This indicates that direct seedings should be completed by December so that seedlings can become established before dry weather. Survival and growth were better when the trees were released from the hardwood overstory by girdling rather than cutting.

Direct seeding of pine is not only cheaper than planting, but the studies indicate that, if initial stocking is adequate, better survival and height growth are obtained. Of the spots that were stocked by direct seeding at the end of the first growing season, 88 percent were still stocked after 16 years, as compared with only 58-percent survival for planted trees in the same plots. The seeded trees also were about 1 foot taller than planted trees of the same age.

Competition from hardwood sprouts reduced height growth of both planted and seeded pines. Under similar conditions, however, the seeded trees were consistently taller at the end of the study. These data indicate that the possibility of direct seeding in establishing pine to convert poor hardwood stands to species that may be better adapted to the site should be further investigated.

Reinforcement Planting in Bottomlands

In most bottomland stands reproduction is ordinarily present or becomes established in sufficient amount to occupy the area after the overstory is removed. However, in many cutover stands there is not enough natural reproduction of the desired species to fully utilize the site. In such stands, the quickest way to fully develop the productive potential is to reinforce the natural reproduction by planting.

In a heavily cutover bottomland area of southeastern Missouri, studies were established to determine the most practicable methods of reinforcement planting. The area was heavily cut a year ago and there is very little natural reproduction and very few seed trees of desirable species (fig. 15A). Herbaceous plants, particularly giant ragweed, aster, and goldenrod, grow very fast (fig. 15B). This makes it necessary to plant relatively tolerant species or control the herbaceous plants before planting intolerant species.



Figure 15.--Heavily cut bottomland stand.
(A) In April seedlings of desirable species were sparse and scattered...



(B) In September giant ragweed averages 15 feet in height and aster and goldenrod are 5 to 6 feet in height. Sweetgum planted in this area had 67-percent survival the first year.

In the past year it was learned that the development of herbaceous vegetation affected the first-year survival of planted sweetgum almost as much as a dense tree canopy. However, foliage sprays with chemicals show promise as a means of controlling herbaceous growth.

Stratification and Seedbed Treatment Improves the Development of Yellow-Poplar Seedlings

Treatment of nursery seedbeds with methyl bromide gas and the use of spring-sown, stratified yellow-poplar seed have resulted in more and better seedlings. At the Vallonia Nursery in Indiana a study is being made to find out how gassing seedbeds and season of sowing affect yellow-poplar seedling production; the largest yellow-poplar seedlings were grown in gassed seedbeds from spring-sown, stratified seed. Part of the test was designed to find out how gassing seedbeds with methyl bromide affects the size and number of yellow-poplar seedlings. Sowing fresh seed in the fall was compared with sowing stratified seed in the spring. The results are encouraging (fig. 16) and the study will be repeated at two nurseries during the 1958-59 season.

Vegetative Propagation of Poplars

Untreated stem cuttings taken from two hybrid poplar clones and a selected Wisconsin strain of cottonwood are being tested on several areas in southeast Iowa. The hybrid poplars, designated the "Sherrill" and "Shimek" clones, are natural crosses of bigtooth aspen and European white poplar found several years ago in two small stands in southeast Iowa. Both clones seem to have superior growth characteristics. In order to propagate these clones a study was begun last spring to determine effects of size of stem cuttings and different times of spring planting on their survival and growth.

The cuttings were made in the preceding dormant season and placed in cold storage. Lengths tested were 8, 12, 16, and 20 inches. These were planted in replicated plots on four dates--April 10, April 24, May 7, and May 24. The basal diameter of each cutting was measured, and it was then planted at a depth sufficient to leave about 2 inches above ground. During the following summer, the plots were mowed twice to reduce weed competition.

Results after one growing season show marked differences in success of the hybrid poplars, caused by both length and diameter of cuttings. Survival ranged from less than 10 percent and growth from less than 1 foot for 8-inch cuttings to more than 30-percent survival and about 3 feet of growth for 20-inch cuttings. Taking 20-inch cuttings as an example, a similar response was noted with regard to the basal diameter of the cuttings. As the diameter increased from less than 1/2 inch to over an inch, survival and growth became several times better.

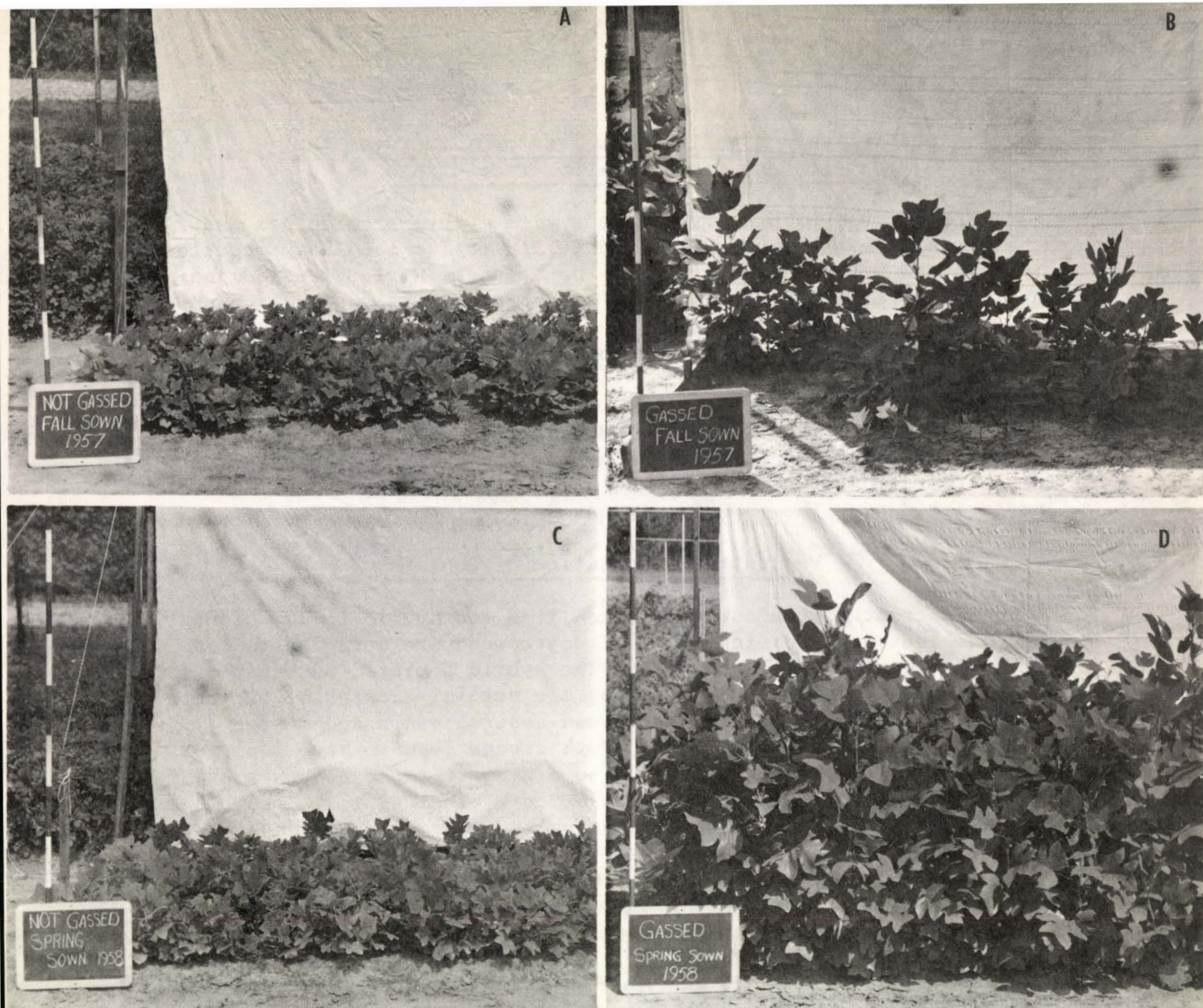


Figure 16.--Effects of seed stratification and seedbed gassing on yellow-poplar seedlings: (A) Fall-sown, ungassed; (B) fall-sown, gassed; (C) spring-sown (stratified seed), ungassed; (D) spring-sown (stratified seed), gassed.

Cottonwood cuttings rooted much more successfully than did those of hybrid poplar, and survival differences due to cutting size were not as pronounced. However, the relationship between height growth and size of the cuttings was similar.

It was thought that the warmer soil temperatures at the later planting dates would promote rooting success, but results of this study showed no significant effects.

Underplanting Decadent Black Locust Plantations

Planting black locust is one of the best ways to rapidly obtain a plant cover on strip-mined land. However, it is subject to attack by the locust borer and for this reason it is frequently desirable to convert severely damaged plantations to a different species.

One of the oldest underplanting studies was made in Illinois in 1947 when 7 hardwood species and redcedar were planted under a decadent black locust stand and 8 hardwood species were planted under a shortleaf pine stand. The black locust stand was 9 years old at the time of underplanting and had been severely damaged by locust borers. The shortleaf pine plantation was 8 years old at the time of underplanting and had been severely damaged by frost and the pine tip moth.

After 12 growing seasons yellow-poplar, black walnut, silver maple, and Osage-orange made better growth under the black locust than under the shortleaf pine. More than half of the black walnut and yellow-poplar were over 30 feet tall. Median heights of ash and sweetgum were about the same under the black locust as under the shortleaf pine; however, survival was much better under the shortleaf pine. Cottonwood was a complete failure under both the pine and locust. A few redcedar survived under the locust for 10 years but by the 12th year they were dead.

In converting decadent black locust stands to other species the growth rate of the underplanted species, development of ground cover, and the time and degree of deterioration of the black locust canopy must be taken into account. Yellow-poplar, black walnut, silver maple, and Osage-orange apparently can grow fast enough under decadent black locust to keep up with or overtop the locust sprouts (fig. 17) that develop after a borer attack. However, this depends upon the time of underplanting and the maintenance of an open locust canopy by continued borer attacks or by release cuttings.

To take full advantage of the beneficial effects of black locust, underplantings should be made at the beginning of heavy locust borer attacks. At this time the ground cover is usually not dense, and the seedlings can take advantage of the maximum period of open locust canopy.

Planting Toxic Strip-Mine Spoil Banks

On some strip-mined land the weathering of sulfur compounds (pyrite, markasite, and poly-sulfides) produces soluble sulfuric acid. On areas where the concentration of sulfuric acid is very

high (pH values of 4.0 or less), planted trees grow very slowly or die. In time, weathering will break down the sulfur-bearing rocks and the soluble toxic materials will be leached from the surface of the spoil banks. But we do not know how many years are required to lower the toxicity of these areas so they can be successfully planted.

A recent study was established in western Kentucky to determine the time required for weathering and leaching to reduce the toxicity to levels that will allow satisfactory growth. Six hardwood and 4 pine species were planted on toxic areas of spoil banks from 1 to 30 years old. After the first growing season the highest survivals occurred on spoils that were more than 6 years old, and pines survived better than the hardwoods.

Species Tests on Spoil Banks

A test to explore the possibility of reclaiming strip-mined land in eastern Kentucky by forestation was started in 1958. This study will provide the information needed on the survival and growth of various tree species on spoil banks. Its objectives are: (1) To determine which of 10 different tree species is best suited for planting on strip-mine spoil banks, and (2) to test the effectiveness of European black alder as a nurse crop for these 10 species. The 10 species being tested are: Shortleaf pine, Virginia pine, pitch pine, eastern white pine, loblolly pine, yellow-poplar, red gum, sycamore, white ash, and cottonwood. After the first growing season white ash, shortleaf pine, Virginia pine, and pitch pine all showed high survival, while sycamore had the lowest survival.



Figure 17.--Five years ago this yellow-poplar was planted under a 15-year-old, decadent black locust stand. The yellow-poplar is now 9 to 15 feet in height and can be expected to overtop the locust in a few years.

SILVICS

Amount of Light on Forest Floor as Related to Stand Density Conditions

For the past 2 years we have been studying quantitative light conditions in the upland forests of southern Illinois. We have used an Integrating Light Meter which gives a cumulative light reading throughout any given period, and an incident light exposure meter which gives instantaneous readings in foot-candles. Light readings have been taken in different-sized openings and in stocking-structure plots of different densities.

An opening about 100 feet in diameter ($1\frac{1}{2}$ times height of surrounding trees) received about half as much light as a station in the open. Even a small opening 30 to 35 feet in diameter ($\frac{1}{2}$ height of surrounding trees) received $\frac{1}{4}$ of full light, twice as much as under a closed oak-hickory canopy and 8 times as much as under a closed beech canopy.

Instantaneous light measurements at 9 a.m., 12 noon, and 3 p.m. from 20 stations on half-acre plots for 3 to 5 days during the summer show that the mean light that comes through the crown canopy (within this range) is roughly proportional to the basal area of the stand. Furthermore, the light intensities under forest stands on southerly exposures seem to be higher than in coves or on east slopes.

Instantaneous light meter readings taken at 10-minute intervals at a particular light station show how light fluctuates on the forest floor during the day (fig. 18). Note how light drops off at about 1:30 p.m. when the trees just west of the light station begin to shade it. On the other hand the morning sun starts to shine fully into the northwest side of the opening (75 by 50 ft.) just after 9:30 a.m. for a period of more than an hour. Seasonal movement of the sun as the summer wanes introduces additional variability. For example, 2 weeks later in August the station in figure 18 has the same peak of light intensity between 9:30 and 11:00 a.m., but the peaks at noon and 1:20 p.m. are greatly reduced.

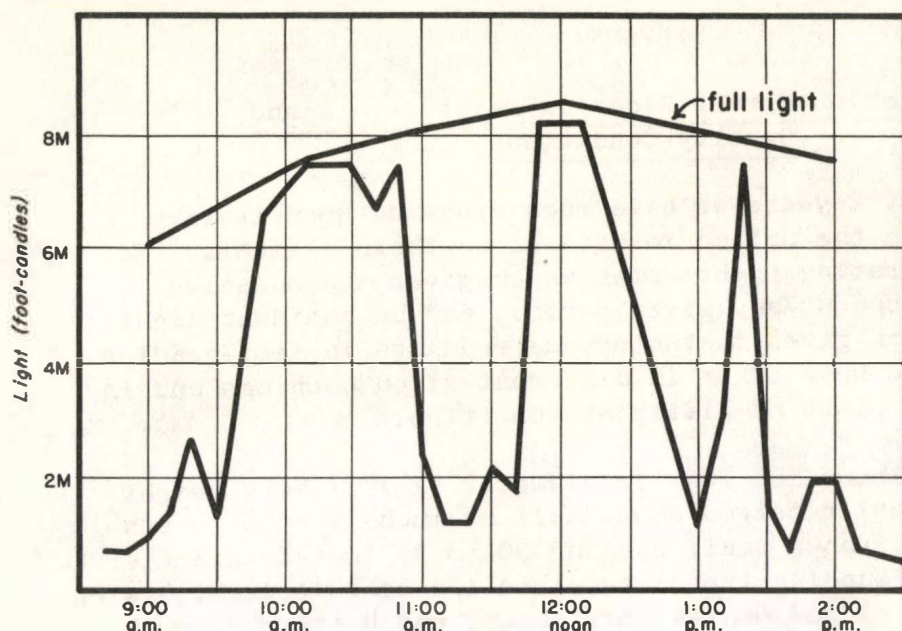


Figure 18.--
Fluctuations in
light taken on
the northwest
side of opening
in canopy 75 by
50 feet, oak-
hickory stand,
south aspect.

STAND-IMPROVEMENT METHODS

Killing Unwanted Trees

Eliminating cull trees is one of the biggest silvicultural jobs to be accomplished in Central Hardwoods. Culls usually constitute 20 to 25 percent of our unmanaged hardwood stands. The known methods of tree killing are not 100 percent effective.

Results testing four methods on an area of upland hardwoods consisting mostly of oaks and hickory showed that the ax frill with 2,4,5-T was the most effective treatment. It was also the most expensive method. However, 90 percent of the treated trees were killed in 1 year, and the cost per killed tree was much less than for the other methods tested. It took 10.8 man-hours of labor and 13.4 gallons of solution to treat 100 square feet of tree basal area.

One man using an ax and pressure sprayer with 2,4,5-T can successfully treat 1 acre, or about 70 square feet of basal area, per day in a Missouri Ozark pole-size hardwood stand.

On some Ozark sites, eliminating the hardwood understory in pine stands may greatly increase annual volume growth of pine, particularly during drouths. Controlling such hardwoods with 2,4,5-T costs about \$15 per acre. The pine volume growth gained on treated areas can be worth about \$4 per acre per year, which means the cost of hardwood control may be recovered in 4 or 5 years.

Also, regeneration of pine at the end of the rotation should be simpler since much of the hardwood understory has been removed.

CMU to Control Hardwoods

Natural and planted shortleaf pine can be released from a low-grade oak overstory by applying CMU on and around the base of the trees to be killed (fig. 19). In the Missouri Ozarks, all overstory hardwoods were killed with 5 to 8 pounds per acre of active CMU applied in 6-inch bands around the trees to be killed. Shortleaf pine was planted in the area. Three years later 68 percent of the surviving 23 pines averaged 3 feet in height.

CMU is especially toxic to pine. Moreover, it washes easily down slopes and sterilizes soils for 3 to 5 years. Therefore, extreme caution must be taken in its use.

TREE IMPROVEMENT

One of the key ways to improve timber quality is to select and grow inherently superior trees. The first step is to determine the variability of a desirable characteristic and then find out how much of this variability is inherited and how much is caused by environment.

Fiber Length of Cottonwood

The Carbondale Forest Research Center, in cooperation with the Forest Products Laboratory and Southern Illinois University, found that mean fiber length increases the faster a cottonwood tree grows in height and diameter and the older the tree. These environmental influences account for 60 percent of the variability in fiber length among the 83 cottonwood trees studied. The remaining 40 percent of the variation is most likely due primarily to heredity. With this information it is now possible to take wood samples from standing cottonwood trees with superior fiber length and determine how much of this superior fiber length will be transmitted to the tree's seedlings.

Figure 19.--Killing individual oak trees with CMU.



Bur Oak Seed Source

The northern form of bur oak (Quercus macrocarpa var. olivaeformis) has acorns about half the size of those of the typical bur oak, and a much smaller and thinner acorn cup. These acorns were reported to germinate in the spring rather than during the fall as did acorns of typical bur oak and other species of the white oak group. Both the large-seeded and small-seeded forms occur in Iowa--the first usually grows on moist bottomland sites where growth and quality of bur oak are frequently good, and the latter is common to dry upland sites where growth is slow and quality is poor.

To check the reported difference in times of germination, acorns from four trees of each bur oak form were collected during the 1957 seedfall. After careful selection for soundness, 10 acorns from each seed tree were planted in each of 5 sand flats. The flats were exposed to subsequent fall and winter temperatures and watered periodically.

Not a single acorn from bottomland seed trees began germinating in the fall, whereas some acorns from each of the upland seed trees did germinate in the fall. Total germination, counting that of the following spring, averaged 90 percent or better except for two bottomland sources.

As might be expected from the difference in acorn size, early growth of the seedlings from bottomland trees was generally superior. Although there was much variation among individual seed-tree sources, by mid-June of the first year the seedlings grown from the bottomland acorns averaged 50 percent taller and heavier than seedlings from upland seed source.

Shortleaf Pine Seed Source

A second provenance test of shortleaf pine from several seed sources verified the superiority of seed from northern and local sources when planted in Missouri, both in wet and in dry years. Survival at the end of the first growing season ranged from 79 percent for trees from Louisiana seed to 94 percent for those grown from local and from New Jersey seed, the northernmost source. Although survival in this second study was much higher than that for trees planted in a dry year, the same correlation was found between good survival and latitude.

Yellow-Poplar Seed-Source Tests

Yellow-poplar, one of our finest upland hardwoods, does not always do well in plantations in the Central States. To find out why, we have begun a comprehensive experiment in which we hope to relate yellow-poplar planting stock quality and plantation development to: Seed source, year of seed collection, nursery treatment, and size of planting stock. Experimental plantations were established in Ohio, Indiana, and Illinois beginning in 1954 and now total 18 blocks, ranging in size from 240 to 1,800 trees.

So far we have found that trees from a Marietta, Ohio seed source are significantly taller than all the others, while those from Illinois are significantly shorter than the rest. There were some striking differences in frost resistance between these sources. Early in May 1957, 80-degree temperature stimulated rapid tree growth of many trees. But on the nights of May 4, 5, and 6 temperatures dropped to below freezing. Most of the trees were frost damaged. However, trees grown from seed produced at the four locations farthest south were much harder hit than those from the three more northern sources. Another interesting although not surprising observation is that taller seedlings survived better than shorter ones.

Seed Development of Yellow-Poplar

Yellow-poplar trees generally produce many seeds but usually less than 15 percent are viable. In cooperation with Southern Illinois University we are studying the processes of seed development in yellow-poplar to find out why this is so.

Present observations indicate that as the seeds develop in early summer all seedcoats are filled with living tissue. Then about August 1 the tissues in most of the seedcoats deteriorate and only a small percentage of seed mature. Why do these tissues deteriorate in late summer? What type of tissues are they?

We are attempting to answer these questions by investigating the different stages in the development of yellow-poplar seed from the formation of the flower through the periods of pollination, growth, and maturity. By making microscopic sections of the flower and the developing seed we can observe under a microscope how a good seed develops and why some seeds fail to develop. After we know why seeds fail to develop it may be possible to develop means for increasing seed viability of selected yellow-poplar trees.

YIELD AND QUALITY

Stocking Structure in Upland Hardwoods

Early growth results on mixed-hardwood sites in southern Illinois show that net growth during the past 4 years is about the same in stands with 80 and 60 square feet basal area. Stands with 40 square feet basal area made somewhat less growth per acre but much more growth per unit of basal area or per unit of volume of the residual stand. Board-foot volume growth was 4.0, 4.5, and 5.1 percent for the high-, medium-, and low-stocking treatments.

The oak-hickory site plots gave different results. Mortality was relatively heavy on the high-stocking plots and growth generally was less than half of that on mixed-hardwood plots. Judging from these early results, 80 square feet basal area is too high for managed oak-hickory stands and even 60 square feet may be too high. Board-foot volume growth was 1.9, 3.6, and 4.1 percent for the high-, medium-, and low-stocking treatments. At this time neither the mixed-hardwood nor oak-hickory plots showed any consistent growth relation to structure (diameter distribution) of the stands.

Growth in Well-Stocked Upland Hardwoods

An oak-hickory stand containing 7,500 board-feet per acre grew 246 board-feet per acre in 11 years. A mixed-hardwood stand containing 7,700 board-feet per acre grew only 227 board-feet per acre during the same period. This is because there were few of the fast-growing species, such as yellow-poplar, in the stand, but many slow-growing, overmature beech.

Red oak grew faster than any other species--2.5 inches in diameter during the 11 years. Hickory, sugar maple, and beech grew only half as fast as red oak while white oaks grew 1.7 inches in diameter. The results of this study indicate a good growth potential for average sites in southern Indiana, although silvicultural practices are needed to improve the species composition in the next rotation.

Eastern Cottonwood Responds to Thinning

A study in cooperation with the University of Missouri and the Missouri Conservation Commission has shown that young cottonwood stands respond to thinning. An 8-year-old stand was thinned from 85 square feet of basal area per acre to 50 square feet. Five years later the trees in the thinned plots had grown 2.4 inches in diameter while those on unthinned plots had grown only 1.7 inches. At 13 years of age the dominant trees were 77 feet

tall. Trees on the thinned plots averaged 9.7 inches in diameter and those on the unthinned plots averaged 8.2 inches. The number of trees per acre was 185 and 268, respectively.

Cubic-foot volume growth has been the same on both the thinned and unthinned stands; however, thinning resulted in more usable wood being added to fewer, straight, well-formed trees while in the unthinned plots part of the growth was on smaller, crooked, or leaning trees.

Managing Plantations

A second thinning was made in a 21-year-old shortleaf pine plantation in southern Indiana (12). The stand was 14 years old when first thinned in 1950 to 80, 100, and 120 square feet of basal area. Average annual basal area growth for the 7-year period ranged from 6.4 square feet per acre on the plots thinned to 80 square feet to 7.4 square feet on uncut plots. Combined yields from both thinnings, in standard cords of rough wood to a minimum top diameter of 3 inches inside the bark, ranged from 8.2 cords per acre for the 80 square feet stocking to 9.3 cords for the 120 square feet stocking.

The volume growth was greatest in the uncut check plots and least in the plots cut to 80 square feet of basal area. Total cubic-foot volume has more than doubled in all plots. Results of this test indicate that for good growth, thinning can be deferred until the stands are at least 20 years old. This will also mean more and better products from the thinnings.

Thinning done in 1949 in a heavily overstocked, 51-year-old white pine plantation at the Amana Experimental Forest appears to have been too late to restore a good rate of growth. Increment borings reveal that growth peaked when the trees were 22 to 31 years old, and basal area growth averaged 8 square feet per acre per year. For the 10 years just before thinning, growth of surviving trees dropped 60 percent.

Three degrees of thinning, plus a check, were tested on 1/5-acre plots and replicated twice. The average basal area per acre left after each treatment was:

<u>Thinning</u>	<u>Basal area</u> (Square feet)
None (check)	238
Light	202
Medium	174
Heavy	145

In the 9 years following the 1949 thinnings, growth response was best in the light- and medium-thinned plots but still had continued to decline from preceding years. Results of this study indicate that white pine plantations suffering from prolonged overcrowding will recover their former vigor very slowly, if at all.

Bole Branches on Released and Pruned White Oak Pole-Sized Trees

The number of live bole branches per tree on pole-sized (5 to 10 inches d.b.h., inclusive) white oak trees in uneven-aged stands in southern Illinois does not differ greatly by location, site class, or crown class. The average tree has 4 to 6 live branches on the bole. In one of our studies some of these trees were released, some were released and pruned, and some were left untreated as checks.

Five years after treatment, it was found that both the released and unreleased unpruned trees had about the same number of live bole branches as originally. Again, this did not vary greatly by location, site, or crown class. The released trees did not sprout new bole branches, but branches already present grew faster on trees that were released as compared to those on unreleased trees.

On the other hand, there was only one-third as many new branches after 5 years on released and pruned trees as originally pruned from the 16-foot section (fig. 20). There was no consistent relationship between new bole branches and place, site, or crown class.



Figure 20.--A white oak pole-sized codominant tree pruned to 17 feet and released from crown competition in an uneven-aged stand.

Pin Oak Pruning

Pole-sized pin oak in stands where trees had been pruned to 17 feet during 3 different seasons showed little resprouting on the boles after 2 years. Furthermore, there were no more sprouts 2 years after pruning than 1 year after. The tree boles that were exposed to light had twice as many sprouts as those that were shaded. Most of these originated from dormant buds located on the interface between old branch stubs, not at the stubs.

Injury to live bark near the pruned stub did not appear to affect bole sprouting or rate of healing. All pruned branches had begun to heal, and after 2 growing seasons the scars less than 1 inch in diameter were about half grown over.

Managing Small Woodlands

The chief objective of the farm woodland demonstration at the Kaskaskia Experimental Forest was to attain sustained yields by making annual cuts and improvement treatments using an individual-tree-selection method of management. Sustained yield depends on (1) growth at least equal to the cut, (2) a diameter distribution that continues to supply trees of harvest size, and (3) the continuous development of reproduction of desirable species. We are now sure that the first of these three conditions has been met by annual cutting. After 9 years it is apparent, too, that the second condition can be met only by a delay of several years in the cutting schedule. The third condition, adequate reproduction, is not being realized with the present method of frequent light cuts on an individual-tree-selection basis.

As reported last year we have made 9 cuts on a 24-acre tract. The tract was divided into three 8-acre blocks and a cut was made in one block each year. In the 9-year period each block was cut three times and a volume of 4,500-5,000 board-feet was harvested in each cut. Despite the fact that a total volume of 42,000 board-feet was cut, the present volume is nearly equal to what we had originally. Furthermore, an average of 66 cull trees per acre was killed during the 9-year period. The cutting of mature and low-quality trees and the killing of cull trees have improved the overall tree quality and species composition of the stand. The proportion of hickory and undesirable miscellaneous species has been reduced by about half.

The undesirable results of the annual cuts includes unbalanced diameter distribution, undesirable composition of reproduction, and loss of time in putting the stand in good condition.

The present stand contains less than one tree per acre 20 inches d.b.h. or larger. There is an adequate number of pole- and small-sawtimber trees, but cutting will now have to be postponed 4 to 7 years before an operable cut can be taken (fig. 21).



Figure 21.--After 9 annual cuts and improvement treatments, most trees on the farm woodland demonstration are vigorous growing stock of good quality.



Figure 22.--Yellow-poplar and oak reproduction in an opening in a cove about 60-70 feet wide and 150-200-feet long. This reproduction is now 8-9 years old.

After 9 years of annual cuts the reproduction totals about 7,000 seedlings and 2,000 saplings per acre. However, only 23 percent of the seedlings and 6 percent of the saplings are the desirable species--oak, yellow-poplar, and black walnut. There are very few openings in the canopy, and the more tolerant and usually undesirable species are developing at the expense of the better, more intolerant species.

On nearby areas where the original stand and site conditions were similar we have found that group-selection cutting is necessary to create conditions for successful reproduction of desired species (fig. 22). Because of our experience with this tract, we believe a group-selection method of cutting in the upland forest types of this area would more fully satisfy the requirements for sustained yield. The initial harvest and improvement cut in unmanaged stands should be heavy enough to eliminate culls and low-quality merchantable trees and to provide openings for reproduction.

PRODUCTS

Our utilization research is aimed at developing more efficient timber-harvesting methods and finding new uses and better processing methods for our hardwoods. Briefly described below are some of the highlights of work during the past year.

PRIMARY CONVERSION

Estimating Quality of Hardwood Trees

Our tree quality research has progressed to the point where we can, with some confidence, predict the quality and value of standing black oak trees in southern Illinois by examining the best 10-foot section of the butt 16-foot log. Further tests of this system show that the value of black oak trees in southeastern Ohio can be predicted with an error of less than 1 percent. It was apparent, however, that additional data are needed to increase the accuracy of the grading system for trees larger than those encountered in southern Illinois. We are also comparing this butt-log grading system with other grading systems and testing it on other hardwood species.

"X-Ray" Technique for Detecting Decay

A portable scintillation spectrometer is being designed and built under provisions of a cooperative project with the Ohio State University Research Foundation. The spectrometer will be tested soon to determine its suitability for detecting presence of decay in standing trees and large timbers in use. The principle is based on attenuation of gamma rays.

Felling and Bucking

A study is being made with the cooperation of one of the power-saw manufacturers to compare the efficiency of different saw types and crew size for felling and bucking hardwood sawtimber.

Tests for the 2-man crew using both direct-drive and reduction-drive saws are now complete. Preliminary analysis of the data indicates that the direct-drive saw required a little more maintenance. But the full story concerning efficiency will not be known until the 1-man crew phase is completed and all the data analyzed.

In these studies "productive work time" includes the time spent felling, limbing, marking for bucking, and bucking. "Travel time" is the time required to move to the next tree. "Non-productive

time" is that used in chain-sharpening, refueling, and for rest periods. These times for a 2-man crew using a 6-hp. chain saw are summarized below:

	<u>Reduction-drive</u> (Percent)	<u>Direct-drive</u> (Percent)
Productive work time	63	59
Travel time	5	5
Non-productive time	<u>32</u>	<u>36</u>
Total	100	100
Man hours per thousand board-feet of logs produced	1.3	1.5

Air-Drying Lumber

Recent adoption of new lumber-handling techniques has rendered some of the previously accepted air-drying practices obsolete and created a need for new methods applicable to modern lumber-handling. The relatively narrow unit packages that lend themselves readily to movement by fork-lift equipment tend to hasten drying of lumber. Serious degrade due to end splitting, surface checking, and warping often develops in oak and some other species when they are air-dried too rapidly. Degrade in unit-packaged lumber can be minimized by retarding air circulation through the pile. However, the proper drying conditions are not yet known, and attempts to control the drying rate may result in over-compensation followed by serious losses due to stain, mold, decay, and insects.

An exploratory study was started to determine: (1) The effect of package width on drying rate and seasoning degrade, (2) the effect of board spacing within a package on the drying rate and seasoning degrade, and (3) the need for, or effectiveness of, various sticker treatments to minimize stain.

Two tests were run, one during a poor drying season and the other during a good drying season (fig. 23). Results indicate that pile width and board spacing had little effect on drying rate and development of degrade in lumber dried during the wet season (table 2). However, during the dry season, both pile width and board spacing affected the drying rate and development of degrade. The high percentage of degrade in lumber piled edge-to-edge was due to sap stain.

The condition of the stickers, whether green or air-dry, treated or untreated, did not affect results.

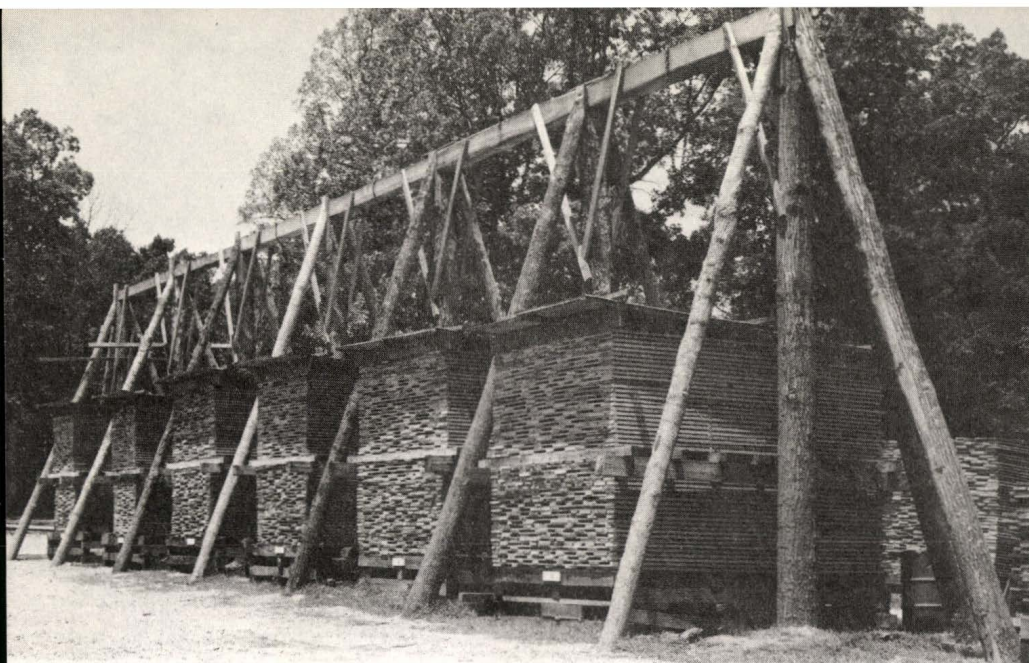


Figure 23.--
Experimental
installation
for study of
air-drying
oak lumber.

Table 2.--Effect of pile width and board spacing
on final moisture content and seasoning degrade

Pile width (feet)	Spacing between boards	Wet season ^{1/}		Dry season ^{2/}	
		Average	Boards	Average	Boards
		final moisture content	degraded	final moisture content	degraded
	Inches	Percent	Percent	Percent	Percent
4	1	24	17	15	8
4	None	22	20	14	19
6	1	25	19	18	19
6	None	25	16	19	52
8	1	23	10	19	8
8	None	24	11	25	43

^{1/} February, March, and April.

^{2/} July, August, and September.

Degrade in hardwoods caused by stain-producing fungi and wood-boring insects can be prevented by dipping green lumber in a fungicide-insecticide solution before piling for drying. Equipment has been provided at our Wood-Products Pilot Plant whereby 3 or 4 men can grade, dip, sort, and stack lumber in one continuous operation (fig. 24). It consists of a grading table, dip tank, and sorting table. Green lumber is carried by endless chains

powered by a 6-hp. gasoline engine from the grading table, through the protective solution in the dip tank, and on to the sorting table. Boards are taken from the sorting chain and piled in stickering racks by grade.

SECONDARY UTILIZATION

Hardwoods for Farm Structures

A study is in progress to find out if small farm structures can be profitably produced from our plentiful native hardwoods. One phase of the study is the production of a hog-feeder from commercial red oak. The cost of oak feeders will be compared to that of softwood feeders produced from currently used materials by currently used methods.

Our study of the "small shop" method of producing hog-feeders from native commercial red oak and softwoods has been completed. This method uses the simplest machinery and the most labor. Results to date indicate that: (1) The cost of oak material per feeder will be approximately \$15.00 to \$20.00 less than that of softwood material now used, (2) labor cost of oak feeders is higher because additional machining is required to convert rough lumber to usable parts, (3) the combined labor and material costs show a savings of approximately \$11.00 to \$13.00 per feeder in favor of oak (table 3). Final unit-cost comparisons cannot be made until equipment, maintenance, depreciation, and overhead costs are taken into account.

The "small shop" method of producing oak feeders uses equipment which can be found in most plants now producing softwood feeders. Other production methods to be tested will require a greater investment in equipment, but manpower requirements (labor costs) will be reduced and production rate will be increased.

Figure 24.--
Green chain
for grading,
dipping,
sorting, and
stacking lum-
ber at the
Wood-Products
Pilot Plant.

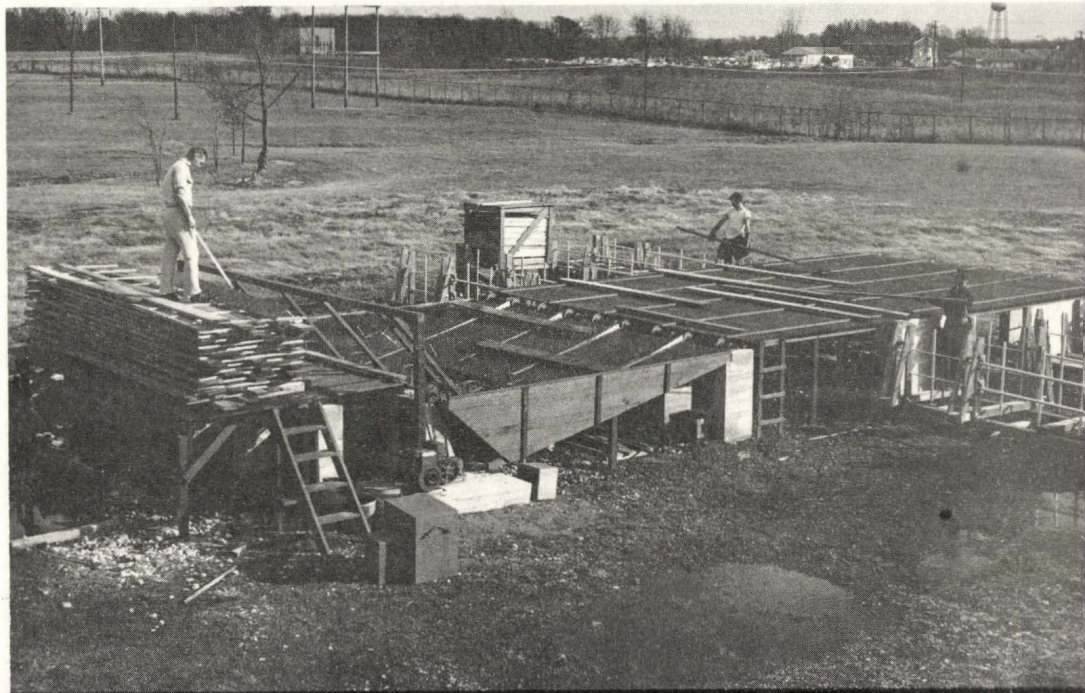


Table 3.--Comparative costs of oak feeders produced by "small shop" method and softwood feeders produced by conventional methods^{1/}
(In dollars)

Item	Oak			Softwood
	No. 1 Common	No. 2 Common	No. 2 Common and poorer	
Wood materials ^{2/}	22.08	17.46	16.01	37.46
Labor ^{3/}	6.86	8.59	11.15	2.20
Total	28.94	26.05	27.16	39.66

^{1/} Six-foot, 12-door feeder requiring 160 net board-feet of oak and 177 net board-feet of softwood material.

^{2/} Cost based on current prices of carload lots of species and grades used, and yields obtained.

^{3/} Cost at \$1.25 per man hour up to, but not including, final assembly of feeders.

Hardwoods for Stadium Seats

Failure of wooden stadium seats may be hastened by the weakening effects of warping, end splitting, and decay which starts around bolts and at end joints. Occasionally splinters develop on the seat surface, making replacement necessary.

In the hardwood regions, hickory is a very difficult species to market. Since it is strong, stiff, hard, and shock resistant, it should be ideal for use in stadium seats. Hickory, however, is low in decay resistance, is subject to insect attack, and is somewhat difficult to dry.

In 1953 a study was begun at Carbondale to test the serviceability of hickory stadium seats. One hundred-twenty hickory seat slats, treated by four different methods, were installed in the Southern Illinois University stadium. Untreated Douglas-fir, which has been used exclusively for seats in this stadium, was included as a control. All test specimens (fig. 25) have since been given the same maintenance as all other seat slats in the stadium. After 5 years of exposure the hickory slats, regardless of treatment, appear to be superior to the Douglas-fir slats.

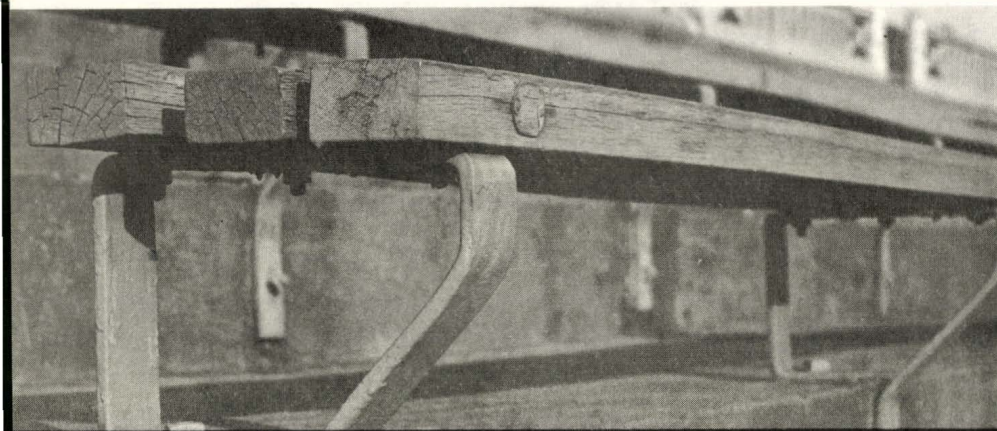
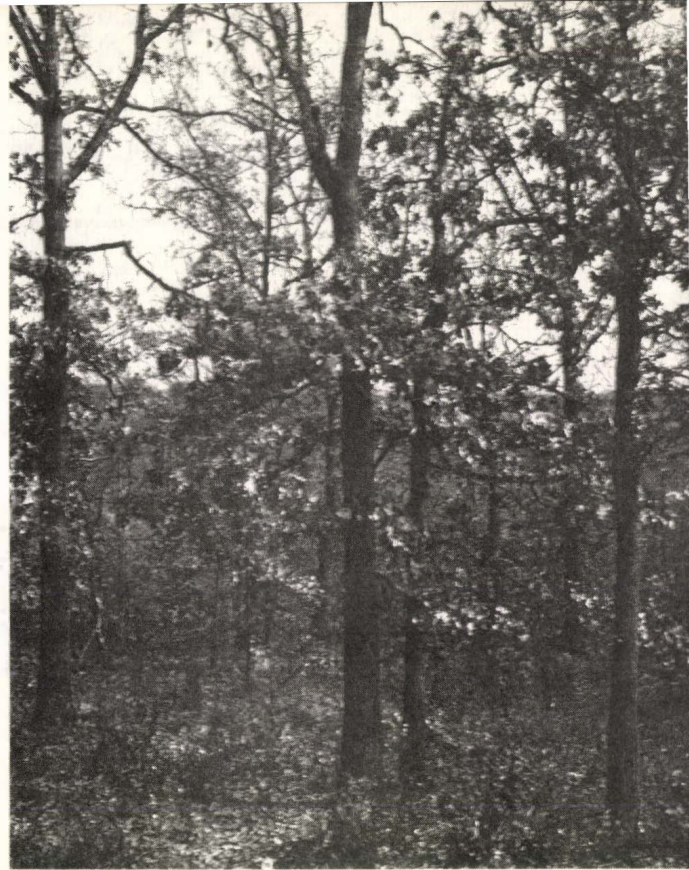


Figure 25.--An experimental hickory seat slat after 5 years exposure in Southern Illinois University stadium.

Figure 26.--A low-quality stand in the western Ozarks consisting mostly of post oak and black-jack oak. Is such land better suited for growing timber or forage?



RANGE

Efficient land use is the ultimate goal of range research, which is concentrated in the Missouri Ozarks. A major problem is deciding if land can better serve all interests producing range forage or growing trees.

RANGE-TIMBER RELATIONS

A research program was begun this year in southwest Missouri to determine capabilities of certain types of forest and range land for forage and timber production, and to find out how to manage these renewable resources (fig. 26). Initial phases of this research program will be concentrated on the deeper soils of the Jefferson City limestone formation area in the western Ozarks.

USE OF FIRE ON LIVESTOCK RANGE

Increases in forage production in low-grade hardwood stands in the Missouri Ozarks were found to be inversely related to amount of hardwood crown cover. However, significant increases in forage production did not begin until forest crown cover was reduced to less than 60 percent. Increased forb production was small per unit reduction in crown cover from 90 percent (fig. 27).

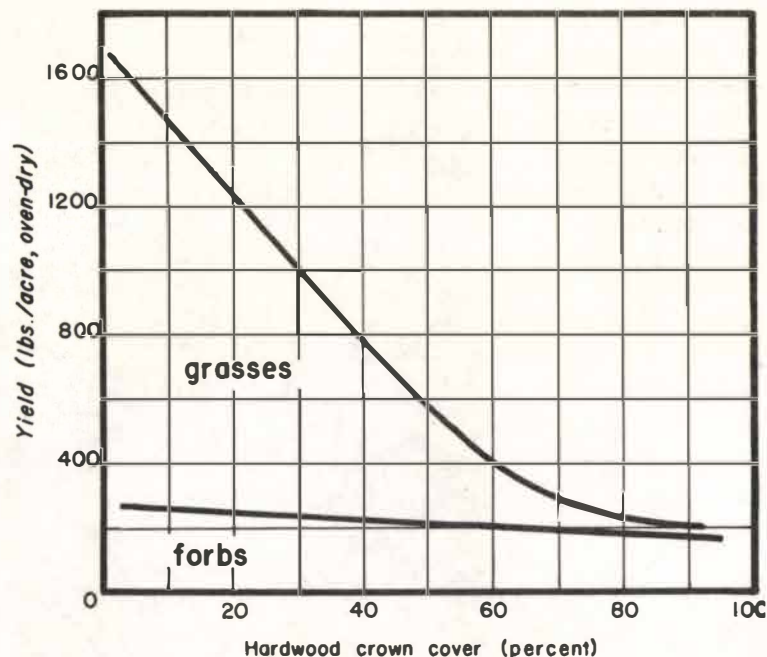


Figure 27.--Yield of grasses and forbs under various amounts of crown cover.

In another study herbicides were usually more effective than burning in decreasing the hardwood crown cover because sprout regrowth on burned areas soon nullifies the "good" done by the fire.

RELEASING PINE BY AERIAL SPRAYING AND HAND SPRAYING INCREASES FORAGE PRODUCTION

Aerial and hand spraying of low-grade hardwoods with 2,4,5-T to release understory pine resulted in increased forage production. Yield of herbaceous vegetation the first year after spraying was 5 to 17 times greater than the check area (table 4). The second year after aerial spraying, forage yields dropped to about one-fourth that of the previous year. Forage production on the hand-sprayed plot continued increasing the second year after spraying and was greater than the yields on aerial-sprayed areas. The third year after spraying, forage yields decreased on areas sprayed once with greatest yield changes occurring in aerial-sprayed plots. The more rapid decline in forage yield on aerial than on hand-sprayed areas was probably due to differences in hardwood sprout regrowth and increased growth of pine.

The 1958 forage production increased over the 1957 yield on the areas receiving two aerial sprays (1955 and 1957). Indications are that forage production trends on areas sprayed twice (in alternate years) will decline in future years as the pine canopy closes. Sprout-regrowth results of this study show there would be some forage for livestock grazing for a few years after pine is released by spraying the hardwood competition.

FORAGE PRODUCTION AS RELATED TO HARDWOOD COMPETITION

K-31 fescue is apparently better adapted to compete with hardwood sprouts than little bluestem. On areas where the low-grade hardwoods were treated in the spring of 1956, forage production increased on plots seeded with K-31 fescue (a sod former) and decreased on plots seeded with little bluestem (a bunch grass). Although fertilizers greatly increased production of K-31 fescue in 1957, a year later there was no difference in production on fertilized and unfertilized areas. This suggests for the central Ozarks there is little or no "carry over" effect of the fertilizer.

Table 4.--Forage production on areas sprayed with 2,4,5-T to release understory pine
(In pounds per acre)

Year	Control	Spraying		
		Hand	One aerial	Two aerial
1955	35	60	50	45
1956	70	335	1,225	1,200
1957	45	360	325	285
1958	40	315	225	430

WATER

Increasing population and associated recreation requirements plus continually growing demands of a multi-billion dollar industry require the 43 million acres of forest land in the midwest be made to yield a sustained supply of good water. The conditions of these forested areas as they convert precipitation to streamflow influence one-fourth of the nation's population residing in the area served by the Central States Station.

Watershed problems in the midwest are so many that the Station can only tackle part of them. We feel that our research effort should be channeled towards understanding more about basic laws and principles in plant-soil-water relations. Only with a better understanding of fundamental biologic, ecologic, hydrologic, and erosion processes can we prescribe new and better practical management practices for forest land.

One of the year's accomplishments was establishment of a new field headquarters office in cooperation with the Muskingum Conservancy District in New Philadelphia, Ohio. Here we will study sub-soil water management, microclimate, vegetation, and other biological factors as they affect development of forest soils, soil stability, runoff, and water yield.

HYDROLOGY OF SMALL WATERSHEDS

Precipitation and runoff records for three small watersheds near Rolla, Missouri were analyzed. The three watersheds differ in size, shape, land use, and cover type. The smallest covers 0.6 square mile and is open land; the middle one is approximately one-third oak forest and two-thirds grain crops and pasture; and the largest is two-thirds in oak forest and one-third grain crops and pasture. During a 7-year period the three areas received an average annual precipitation of 38 inches. However, the range was great--from 18 to 65 inches.

In predicting annual water yields from annual precipitation in this area, it was found that a water year commencing June 1 and ending May 31 gave the best correlation. The national water year starting October 1 should generally be avoided then when working with small Ozark watersheds from 0.6 to 14 square miles.

The frequency and magnitude of storm peaks usually vary inversely with watershed size. This means smaller watersheds generally have more and higher peaks than do larger watersheds. During this 7-year period the smallest watershed had 96 peak flows exceeding 40 c.s.m. (cubic feet per second per square mile) while the middle-sized had 65 and the largest 44. The smaller watershed had more storms in the higher peak classes with one maximum of 2,800 c.s.m. Furthermore the majority of peaks occurred during the growing season.

FOREST-SOIL-WATER RELATIONS

A soil-moisture study in southeastern Ohio has contributed information on the influence of clear cutting a poor-site oak stand upon disposition of precipitation. All trees and other woody vegetation were cut on several 1/2-acre blocks in 1953 and pine was planted in the spring of 1954.

Clear cutting has had little effect upon the amount of forest floor, surface water runoff, or soil erosion in the first 5 years. It has had a more marked effect upon the content of moisture in the soil profile. This soil, a thin Rarden clay loam with a 3-to-4-inch thick, medium-textured surface layer and a 30-to-40-inch thick, heavy-textured subsoil, can retain about 13 inches of precipitation (table 5).

Table 5.--Depth and retention soil moisture storage of
Rarden clay loam
(In inches)

	Total	Horizon		
		A	B	C
Depth	36.0	4.0	13.0	19.0
Retention storage	12.9	1.2	4.5	7.2

Soil-moisture differences were largest the first growing season after cutting. In 1954 total soil-moisture depletion was 6.6 inches under uncut forest but only 3.4 under clear cut, a difference of 3.2 inches. The 1955 soil-moisture depletion was 7.1 inches under uncut and 4.8 inches under clear cut, a difference of 2.3 inches.

Even in this shallow soil, clear cutting the mixed oak forest can affect water available for streamflow because it takes less dormant-season precipitation to wet the soil enough for percolation of water to groundwater storage or become available for streamflow. Recharge in 1953 began about October 1, shortly after the end of the growing season. On the clear-cut plots it was completed in early winter, but on uncut the soil was still being recharged until late winter or early spring. Also the date when soil-moisture depletion began was delayed about a month by clear cutting. This study also showed that in southeastern Ohio the soil can become recharged during the growing season to the extent that some of the summer precipitation goes to streamflow.

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- * Boyce, Stephen G. and Parry, Robert E.
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(Chances of obtaining natural regeneration of yellow-poplar are better in open areas than under dense canopies and are better on the surface of the soil A horizon or on well decomposed organic matter than on undecomposed organic matter or on the surface of the soil B horizon.)
- Bretz, T. W. and Jones, T. W.
Oak wilt distribution through 1957. Plant Dis. Rptr. 42(5): 710, illus.
(Brings up to date the known distribution of oak wilt in the United States by counties--map included.)
- Buchanan, W. D.
Oak wilt vector studies in Missouri. Proc. Thirteenth Annual Meeting North Central Branch, Ent. Soc. Am., 13: 9-10.
(Brief summary of the results of oak wilt vector studies involving caged and field tests with barkbeetles and infections through wounds.)
- Buchanan, W. D.
The small oak barkbeetle transmits the oak wilt disease under caged conditions. Plant Dis. Rptr. 42(4): 546.
(Oak wilt developed in 1 of 117 red and pin oak seedlings fed upon by about 120,000 beetles that emerged from sections of diseased trees. The disease developed in 1 of 87 seedlings that were fed upon by about 20,000 beetles reared from diseased trees and placed directly into cages enclosing all or parts of the test seedlings.)

* Available for distribution.

* Buchanan, W. D.

The small oak barkbeetle transmits the oak wilt disease. Jour. Forestry 56(6): 414-415, illus.

(Oak wilt developed in 2 of 204 caged oak seedlings fed upon by about 140,000 beetles that emerged from sections of diseased trees.)

* Carmean, Willard H.

Silvical characteristics of yellow buckeye. Misc. Release 29, 16 pp., illus.

(Summary of available information on silvical characteristics of yellow buckeye. Covers distribution, habitat, life history, and special characteristics. Bibliography included.)

* Central States Station

1957 Annual Report, 74 pp., illus.

(Reviews Station's activities and accomplishments for 1957.)

Clark, F. Bryan

Direct seeding yellow-poplar. Jour. Forestry 56(5): 351.

(Direct seeding shows promise as a method of establishing yellow-poplar in forest openings.)

* Clark, F. Bryan

Silvical characteristics of swamp white oak. Misc. Release 25, 10 pp., illus.

(Summary of available information on the silvical characteristics of swamp white oak. Covers distribution, habitat, life history, and special characteristics. Bibliography included.)

* Clark, F. Bryan

Silvical characteristics of butternut. Misc. Release 28, 9 pp., illus.

(Summary of available information on the silvical characteristics of butternut. Covers distribution, habitat, life history, and special characteristics. Bibliography included.)

* Clark, F. Bryan and Williams, Robert D.

Cubic foot volume tables for planted shortleaf pine. Sta. Note 121, 2 pp.

(Volume tables for plantation grown shortleaf pine are presented and a factor is given to convert merchantable cubic foot volume of peeled wood to standard cords of unpeeled wood.)

- * Clark, Wendell P. and Headlee, Thomas M.
 Roof your lumber and increase your profits. Forest Prod. Jour.
 8(12): 19A-21A, illus.
 (Shows the savings that can be realized from the use of roofs
 on air-drying piles of red oak lumber in southern Illinois.)

- Crosby, John S.
 Fire danger meters. Proc. R-9 Fire Meeting, June 1958: 31-36
 (Review of fire danger rating concepts and current work in fire
 danger rating.)

- * Dale, Martin E.
 Ground treatment and seed supply influence establishment of
 shortleaf pine reproduction. Sta. Note 119, 2 pp., illus.
 (Adequate initial stocking of shortleaf pine reproduction was
 obtained on bulldozed and disked plots with 6 or more good
 seed trees per acre.)

- * Deitschman, Glenn H.
 Silvical characteristics of bur oak. Misc. Release 27, 17 pp.,
 illus.
 (Summary of available information on the distribution, habitat,
 life history, and special characteristics of bur oak. Bibliog-
 raphy included.)

- Donley, David L.
 Systemics in pest control. Thirteenth Midwestern Shade Tree
 Conf. Proc. pp. 8-10.
 (Reviews systemic materials now used and compares these materi-
 als with conventional insecticides.)

- Donley, David L.
 Use of systemic insecticides on forest and shade trees. Proc.
 Thirteenth Annual Meeting North Central Branch, Ent. Soc. Amer.
 13: 74.
 (Describes bioassay methods used in determining systemic in-
 secticide metabolite residues in forest trees.)

- * Finn, Raymond F.
 Ten years of strip-mine forestation research in Ohio. Tech.
 Paper 153, 38 pp., illus.
 (Summary of the results of studies in reforesting spoil banks
 in Ohio.)

* Funk, David T.

Frost damage to yellow-poplar varies by seed source and site. Sta. Note 115, 2 pp.

(Yellow-poplar grown from seed from seven seed sources showed pronounced differences in frost damage. Location of plantations on upper or lower slopes was also an important factor.)

Hay, C. John

Life history and control of a root collar borer (Euzophera ostricorella Hulst) in yellow-poplar. Jour. Econ. Ent. 51(2): 251-252.

(When this phloem borer threatened mature yellow-poplar in western Kentucky in 1954 remedial and preventive control tests were installed.)

* Hutchison, O. Keith

Use the wedge with a staff compass. Sta. Note 123, 2 pp., illus. (How to mount and use the glass prism or "wedge", used in the Bitterlick system of plotless cruising, on a staff compass.)

Jones, T. W.

Mortality in wilt infected oaks. Plant Dis. Rptr. 42(4): 552-553.

(A survey shows that few, if any, trees of the red oak group survive oak wilt infection but more than half of the infected trees of the white oak group appear to recover completely.)

Jones, T. W. and Bretz, T. W.

Experimental oak wilt control in Missouri. Univ. of Mo. Res. Bul. 657, 11 pp., illus.

(Oak wilt control measures consisting of isolation of diseased trees by poisoning surrounding healthy oaks, sanitation by cutting and burning diseased trees, and a combination of both treatments were tested for a 5-year period in Missouri. None of these treatments resulted in control of the oak wilt disease.)

Jones, T. W. and Bretz, T. W.

First report of tree mortality from Fomes annosus root rot in Missouri. Plant Dis. Rptr. 42(8): 988.

(Reports the first known occurrence of this disease as a parasite in Missouri and describes the damage caused.)

* Krajicek, John E.

Silvical characteristics of hackberry. Misc. Release 31, 11 pp., illus.

(Summary of available information on the distribution, habitat, life history, and special characteristics of hackberry. Bibliography included.)

Limstrom, G. A.

Stratify yellow-poplar seed or sow directly? Tree Planters' Notes No. 32: 3-4.

(Stratified spring-sown seed from five different sources from Ohio and Illinois produced a much higher percentage of seedlings than unstratified seed sown in the fall; for two Indiana sources the reverse was true. But for all sources stratified seed resulted in the production of a significantly higher percentage of plantable seedlings.)

Loomis, Robert M. and Stephens, Virgil

Fan psychrometer. Fire Control Notes, 19(4): 136-137, illus.

(Describes a high speed blower for use in finding relative humidity at fire danger stations.)

* McCauley, Orris D. and Quigley, Kenneth L.

Forest products prices in Ohio--1957. Tech. Paper 157, 13 pp., illus.

(Gives prices being paid in Ohio for sawtimber, veneer timber, cooperage timber, handle timber, pulpwood, posts and mine props.)

* McCauley, Orris D.

Pulpwood prices and measures in the Central States. Sta. Note 124, 2 pp.

(Discusses expanding pulpwood markets, kinds of wood, measures used, and prices.)

* McCauley, Orris D.

1957 Pulpwood harvest - Central States. Sta. Note 120, 2 pp.

(The six central states produced nearly 1/4 of a million standard cords of pulpwood in 1957, amounting to a gross value of more than 3 million dollars.)

McGinnies, William G.

Central States Forest Experiment Station. Resource Conserv. 7(7): 3.

(Briefly describes the organization of the Station and its major work in Ohio.)

- * Merz, Robert W. and Boyce, Stephen G.

Reproduction of upland hardwoods in southeastern Ohio. Tech. Paper 155, 24 pp., illus.

(A study of the tree reproduction after clear cutting, heavily cutting, and lightly cutting upland hardwood stands showed that some hardwood species were affected by the degree of cutting and the composition of the original stand. The paper presents the densities and frequencies of tree reproduction, the cover of competing plants, and the application of the results to similar areas.)

- * Merz, Robert W.

Silvical characteristics of American sycamore. Misc. Release 26, 20 pp., illus.

(Summary of available information on the silvical characteristics of American sycamore. Covers distribution, habitat, life history, and special characteristics. Bibliography included.)

Mitchell, Glen H. and Quigley, Kenneth L.

Christmas tree purchasing habits of greater Columbus, Ohio consumers--1956. Ohio Agr. Exp. Sta., Dept. Agr. Econ. and Rural Sociol., Mimeo A. E. 287, 9 pp. plus illus.

(Explains Christmas tree and greenery purchasing habits of consumers in a metropolitan center.)

- * Minckler, Leon S.

Bottomland hardwoods respond to cutting. Tech. Paper 154, 10 pp., illus.

(A study of growth and reproduction after four cutting and stand-improvement treatments showed that both growth and reproduction made a definite response to the treatments. Growth of reproduction in cut openings was rapid and the relatively high quality residual stands grew as much as the heavily stocked check plots.)

- * Minckler, Leon S. and Green, Alan W.

Upland hardwoods form classes. Sta. Note 118, 2 pp.

(Based on measurements of nearly 1200 trees form classes are given for 8 species of upland hardwoods, including white oaks, black and red oaks, hickory, and yellow-poplar.)

- * Quigley, Kenneth L. and Hornbeck, Benn L.
Marketing Kentucky timber. Ky. Agr. Exp. Sta. Bul .. 655,
47 pp., illus.
(Discusses markets for stumpage, logs and bolts and the methods
of marketing this timber; considers relation of timber resources
to wood-using industries needs, and opportunities for expansion
of wood-using industries in Kentucky.)

- * Quigley, Kenneth L. and Mitchell, Glen H.
Ohio-grown Christmas trees--production and marketing. Tech.
Paper 152, 17 pp., illus.
(Describes the production and marketing activities of Ohio
Christmas tree growers. Lists number and species of trees
planted and sold and the prices being paid for them.)

- Rivas, Alfred M. and Buchanan, W. D.
A new technique for rearing carpenterworms. Jour. Econ. Ent.
51(3): 406-407, illus.
(Describes a technique to rear carpenterworms in the laboratory
so they can be observed.)

- * Roach, Benjamin A.
Silvical characteristics of black locust. Misc. Release 30,
15 pp., illus.
(Summary of available information on silvical characteristics
of black locust. Covers distribution, habitat, life history,
and special characteristics. Bibliography included.)

- * Roach, Benjamin A.
Heavy "thinning" is poor practice in mature shortleaf pine.
Sta. Note 116, 2 pp.
(Cutting nearly half the volume in a mature shortleaf pine
stand in Kentucky resulted in a net loss of growth in the pine
and encouraged the development of a profuse hardwood understory.)

- * Rogers, Nelson F.
Airplane-sprayed herbicides release shortleaf pine from hard-
woods. Sta. Note 117, 2 pp. (Also printed in South. Lumber-
man 197(2457): 36 and Forest Notes, American Pulpwood Assoc.)
(Shortleaf pine can be released from unwanted hardwood compe-
tition by spraying from an airplane a 5 gallon solution of 2
pounds of either 2,4,5-T or 2,4,5-TP acid and fuel oil per acre.)

Rogers, Nelson F. and Wray, Robert D.

Federal Forestry Service protects and fosters our Ozarks timber.
Ozarks Mountaineer 6(6): 13, 18, illus.

(A story of research on Sinkin Experimental Forest written in popular style.)

* Ryker, Russell A.

Conifers vs. hardwoods on old-field sites. Sta. Note 122,
2 pp., illus.

(Results after 11 years show that several species of conifers planted on eroded old fields had made good growth. Several species of hardwoods, however, had low survival, and poor growth and form. Results are related to site conditions.)

* Thornton, Philip L. and Hutchison, O. Keith

Cumulative-volume tally sheets for point sampling. Sta. Note 114, 2 pp.

(Explains and illustrates a tally sheet for direct recording of estimated volume using point sampling techniques.)

* Whitmore, Roy A.

Air-drying lumber to increase mill profits. Tech. Paper 158,
9 pp., illus.

(Shows how small sawmill operator can increase his profits more than \$10 per thousand board-feet by air-drying his lumber to reduce shrinkage, sap stain, and end splitting and checking.)

* Whitmore, Roy A.

Bundling hardwood slabs for better marketing. Sta. Note 113,
2 pp., illus.

(Describes the bundling of sawmill slabs for charcoal and wood-chip markets.)

* Whitten, Russell R. and Swingle, Roger U.

The Dutch elm disease and its control. U. S. Dept. Agr. Inform. Bul. 193, 12 pp., illus.

(Discusses importance, symptoms, and control of the Dutch elm disease.)

Williamson, M. J.

Forestry development in Appalachia. Mountain Life & Work 34(1): 8-13, illus.

(Presents a program for forest development in the Southern Appalachian Region.)

* Worley, D. P.

Pulpwood or Sawlogs? From small hardwood trees. Tech. Paper 156, 7 pp.

(Gives general factors for converting rough cords to board-feet, peeled cords to rough cords, as well as the average number of trees to make a cord and methods of comparing stumpage values for different products.)

Wray, Robert D.

Save those elms! Horticulture 36(5): 268-269, 287, illus.

(Alerts the homeowner to the danger of the Dutch elm disease and describes control methods.)

REPRINTS OF PREVIOUS PUBLICATIONS

Liming, Franklin G.

Homemade dendrometers. Forest Equip. Notes, Food & Agr.

Organization of the United Nations, Rome, Italy.

(Describes how to make and use a simple, homemade dendrometer for accurately measuring small changes in tree stem circumference.)

Reprint of Jour. Forestry 55(8): 575-577.

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